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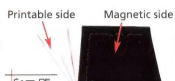

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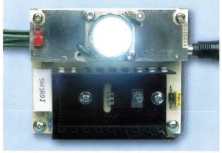

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PUBLISHER'S LETTER

Australian power stations should be solar or gas-fired

With the recent NSW government rejection of the proposed Redbank coal-fired power station in the Hunter Valley, it is clear that we are going to need some other solutions to our increasing energy needs. Before too long in New South Wales we are going to need some more power stations, maybe in only a couple of years. After all, we are not going to want to buy electricity from other states, even presuming that they will have any to spare.

There is at least one other coal-fired power station proposal on the table, the one gigawatt plant at Ulan but given the decision on Redbank, it is unlikely to go ahead. At least, we hope not. But we need more thermal power stations otherwise we are going to have severe power shortages in years to come. So if not coal-fired, what is available?

In the short term, the answer is gas-fired power stations as these have considerable advantages over coal. First, we have an abundance of natural gas and as well as selling it to China and elsewhere, we should be using it ourselves to generate power. It does not have the enormous cost of extraction associated with coal and it does not leave a huge scar on the landscape, as with open-cut mines and drag-lines. Granted, a pipe-line is needed to get the gas to the power station but even this has far less of an effect on the environment than rail or road transportation.

But the real advantage of a gas-fired power station is the very big increase in efficiency brought about by the high temperature of the gases used to drive the gas turbines. After driving the turbines, there is still enough energy left in the high temperature exhaust gases to drive a boiler and steam turbine. Without going into thermodynamic theory, the efficiency is directly proportional to the difference between the heat source (ie, burning gas driving the turbines) and the heat sink (ie, essentially ambient temperature). In a gas-fired power station, the heat source temperature is much higher than in a coal-fired station, hence efficiency is higher.

Not only that, the combustion products of water vapour and carbon dioxide are benign compared to those of coal. Nor are there huge piles of ash to be disposed of. So clearly, since we must have more thermal power stations, they should only be run from natural gas.

In the long run though, we should be looking to solar power generation on a large scale. This is a project for federal and state governments. Considering the typical price of a large power station, a billion dollars or more, we could get a considerable solar generation industry off the ground in this country for that sort of money.

The brief: build a 100 megawatt or bigger solar power station connected to the grid. The solar arrays are pretty straightforward and the electronics of the inverters needed to change DC to AC are hardly hi-tech these days either. Then there would be high voltage step-up transformers and a switchyard, plus high voltage transmission lines to connect to the grid. None of this is rocket science and after the first one was built, the following ones would be easy.

So why not email or write to your local politician and help get the ball rolling.

Leo Simpson

Need something more than just computers?

Hot New Product

USB Port Extender
Extends a USB 1.1 port up to 50m using Cat5 UTP cable. Ideal for setting up low cost web cams etc.
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Cat 11666

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Adapter Dual Keyboard - PS/2
Cat 15091-7 **Adapter Dual Keyboard - PS/2** $159
Connect a Keyboard and Mouse to Your Notebook via the USB
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Cat 15092

All Aluminium SATA Mobile Rack
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Cat 8574

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Monitors have much higher stability and resolution than a TV set. Capitalise on this by turning your monitor into a TV
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Cat 3525

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Read bar codes without cords. Wirelessly transmit the bar code back to your computer in real time. One base station supports up to 16 laser guns. Great battery life with a lithium ion rechargable battery.
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Avoid running mains power cables to remote ethernet devices. This sophisticated unit transmits power at 48 Volts DC to minimise the current. This is then reduced to 5 Volts for the equipment.
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Cat 15141-7 **1 Port** $259
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Cat 17084

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Cat 1008039

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Cat 8866-7 **Bar Code Laser Scanner** $329

Cat. 8866

Omni-Directional Laser Scanner
Get the same bar code reading capability as the big super markets! An affordable, vertically mounted, small footprint, omni-directional laser scanner. It is ideally suited to checkouts of all types, eg newsagents, convenience stores etc.
Cat1008085-7 **Omni-Directional Laser Scanner** $999

USB Macro Input Devices
Close a Switch to Play a Macro This unit would be an ideal adjunct to the home/office web-based surveillance, allowing switching from, say pressure mats, PIR detectors, window switches, etc. Would also have an immense number of applications for people with varying disabilities where complex commands could be executed at the "bump" of a switch.
Cat 8936-7 **Keystroke Macro - USB** $299

Cat 8936

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Store multiple keystrokes at the tap of a footswitch. See also Cat 8936 for multiple macros.
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Cat 15135

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Cat 8935-7 **58 Key Programmable Keypad** $479

Cat 8933
Cat 8935

Video Signal Conditioner
Clean up video signals to provide a stable picture when recording. It provides a bright steady picture on your TV.
Cat 3460-7 **Video Signal Conditioner** $169

Cat 11416

Wireless LAN Amplifier
Boost the output of your base station to the maximum allowed. Ideal for Wireless ISPs. AGC maintains output at 500mW. Enclosed in a weatherproof housing.
Cat 11416-7 **Booster Amplifier** $729

USB Christmas Tree
Get into the spirit of things this Christmas with this great desk sized Christmas tree!
Cat 2909-7 **USB Christmas Tree** $15

USB 2.0 Gear
Cat 2843-7 **USB 2.0 Card 5 Port PCI 480 Mbps** $65

Cat 2843

PCMCIA ATA Card Reader
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Cat 6785-7 **Mem Card Rdr/Writer** $*

Cat 6785

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xD Card Reader
6 in one - Will read and write eight different cards including xD,
Cat 6786-7 **Mem Card Rdr/Wrtr xD USB 2.0** $*

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AM stereo website

Here is a website that is run by AM stereo supporters:

www.amstereoradio.com

The site contains history and information about AM stereo and links to where you can buy new AM stereo capable CD and Mini Disc players. It also tells you where you can buy AM stereo conversion kits and you can order a low-power AM stereo transmitter. Finally, you can also support the petition about the scarce availability of AM stereo radios to at least increase the chances of making the AM band into another high-fidelity solution in the future besides FM.

Chris O'Reilly,
via email.

Analog computers wanted

Years ago, I was involved with the now dead technology of analog/hybrid computers, without which at the time, events like the Moon landing could not have occurred. They essentially were general-purpose scientific simulators using op amp technology.

I am looking for any surviving examples of the smaller machines such as the EAI TR20, TR48, 480 or 580 desktop systems which every university and tech college used. Perhaps some readers might also be able to put me in touch with "analog" PC simulator software. I would also like any recommendations on good electronic design "freeware" for PCs.

Rod Cripps,
60 Herbert Street,
Parkdale, Vic 3195.

Dodgy power cord on vintage radio

I refer to the excellent articles on Vintage Radio by Rodney Champness. Page 90 of the August 2003 edition shows a radio with a 2-wire power cord. I would like to suggest that an approved 3-wire cord should be installed as part of the restoration of a mains-operated radio. Besides being a safety feature this could be mandatory under local regulations.

The electrolytic capacitors in this set would be nearly 50 years old. Again I would suggest it would be prudent to replace these as a matter of course with new ones.

Ted Baker,
Bathurst, NSW.

Comment: we have spoken to Rodney Champness and he agrees that he normally would have changed the cord in the course of restoration.

Valve preamp welcomed

Congratulations on the excellent article on the valve preamp in the November issue. I cut my teeth on valve circuitry and realise the extensive amount of research that must have gone into the design.

Hopefully the valve exponents will be satisfied. It is of little comfort to realise that an op amp equivalent would have taken up about half of the magazine space, used a lot less room, given much better distortion figures, produced very little heat and not needed the high tension voltage.

Chris Potter,
Kilsyth, Vic.

Query on valve amplifier distortion

That was an interesting article you published for a valve preamplifier circuit in the November issue, especially the B+ supply for it. As far as the distortion performance goes, haven't there been valve power amps with similar performance (Williamson 15W @ 0.1%) since the late 1940s?.

Mark Harriss,
via email.

Comment: both the Williamson amplifier and the Mullard 10/10 in the sixties claimed 0.1% or less and Quad, McIntosh and a few others would probably have made similar claims. However, it is doubtful whether that would have applied over the full frequency range and up to full power.

Running a Luxeon 1W star from 3.6V

I love your LED torch projects! I have been playing around with the 1W Luxeon. In my case, I wanted a light, long-life headlamp for bushwalking and camping. It needed to throw a long beam to illuminate the track and also a less intense beam for cooking and other camp activities.

Initially, I thought of the Picaxe. Using PWM and a transistor to drive the LED and a variable resistor to set the output seemed to be the answer. I found that I was limited to either four rechargeable AAA cells or three alkaline ones as a suitable power source because of the Picaxe's peculiarities. In the result, I had a clumsy unit that only just drove the Luxeon at 350mA. I also had an unreliable wired PC board that failed at the most inopportune times (eg, when I was perched on a ledge).

I gave up on that idea and drove the Luxeon directly off my Mobile phone battery (3.6V Li-Ion rechargeable). This works well and the battery drives the LED at full power when needed. I added a small white LED (drawing 20mA) for use in camp.

Your "best torch project" has made me aware that the heatsink I used was probably overkill and I will grind it down to reduce the size of my unit.

Henry Berenson,
Macgregor, ACT.

Loves the valve preamp

I loved the valve preamp. I'm now looking forward to a series of "Little Jim" radios with 3S4 audio valves and 67.5V "B" batteries which takes a week of wages to pay for!

It is great to see SILICON CHIP is moving ahead with the times.

Dick Smith,
Terrey Hills, NSW.

It may be ancient technology but these old ex-NSWGR CPH rail motors are now fitted with up-to-date high-brightness LED assemblies for use as marker lights.

24V LED lights up vintage rail-motor

I was a little amused to read the reply to a query on the "Ask Silicon Chip" pages in the October 2003 issue. This stated that it is impractical to operate your LED stop lights from 24V.

Just to set the picture, I belong to the Rail Motor Society which operates restored NSWGR CPH rail motors commercially. At times, we park our vehicles in refuge rail sidings at stations when we stop for the night – Katoomba being one example. The signalmen like to see a red marker light displayed on the vehicle facing the outgoing road.

To operate our normal marker lights, which use 24V 25W GLS lamps, we could take over 12 amp-hours from our batteries over night. On cold Katoomba winter mornings, that much off the battery capacity can lead to great starting difficulties. So when I saw your LED stop lights in the March 2003 issue, I had the solution.

I made up the units using high intensity white LEDs from Oatley Electronics. These require about 3.5V at 20mA. To achieve this, from our 24V nominal supply, I used 430Ω resistors for each group of four. This gave the current I required and the resistors each dissipate about 0.2W. I also made up one light with high intensity red 2V LEDs operating at 26mA Each resistor in that unit only absorbed 0.4W, a total of 1.2W.

Our standard marker light normally has a BC lamp. So I used a normal BC adapter as the base for the LED array. The only catch was that I had to re-orient each lamp holder and adjust the polarity so that the LED array, when facing outwards (the only logical placing), had the correct polarity.

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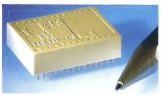
The Tiger comes to Australia

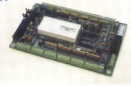


The BASIC, Tiny and Economy Tigers are sold in Australia by JED, with W98/NT software and local single board systems.

Tigers are modules running true compiled multi-tasking BASIC in a 16/32 bit core, with typically 512K bytes of FLASH (program and data) memory and 32/128/512 K bytes of RAM. The **Tiny Tiger** has four, 10 bit analog ins, lots of digital I/O, two UARTs, SPI, I²C, 1-wire, RTC and has low cost W98/NT compile, debug and download software.

JED makes four Australian boards with up to 64 screw-terminal I/O, more UARTs & LCD/key-board support. See JED's www site for data.

TIG505 Single Board Computer



The TIG505 is an Australian SBC using the TCN1/4 or TCN4/4 Tiger processor with 512K FLASH and 128/512K RAM. It has 50 I/O lines, 2 RS232/485 ports, SPI, RTC, LCD, 4 ADC, 4 (opt.) DAC, and DataFLASH memory expansion. Various Xilinx FPGAs can add 3x 32bit quad shaft encoder, X10 or counter/timer functions. See www site for data.

$330 PC-PROM Programmer

This programmer plugs into a PC printer port and reads, writes and edits any 28 or 32-pin PROM. Comes with plug-pack, cable and software.

Also available is a multi-PROM UV eraser with timer, and a 32/32 PLCC converter.

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Mailbag: continued

The standard marker light has a red glass filter that can be swung across and behind the lens when the lower handle is rotated. I made one lower marker (which is not now used for any standard indication) a dedicated redlight only. But after that, I made them all with white LEDs and we use the red filter glass when we require a red light (at the rear of the train).

Everyone is amazed at the results. The penetration of the white LEDs is more visible than from a standard incandescent filament. When the red filter glass is moved across, the result is also brilliant.

The others think I am a genius but it is easy to copy someone else. Thank you for a great idea.

Jim Lowe,
Heatherbrae, NSW.

Comment: your idea of using white LEDs is great but we still stick to what we said in the October issue because you have to allow for the very considerable rise in temperature in taillight assemblies on hot summer days, particularly when the lights (brakes or otherwise) are on for long periods.

Alternative to paint stripper

Congratulations on the October project "A Dirt Cheap High-Current Bench Supply", using a PC power supply. Can we have more articles on the reuse of old computer bits?

There is an alternative to paint stripper for ungluing the ferrite transformer. The tape around the outside of the transformer can usually be removed with a knife. Ten minutes in boiling water will soften the glue, maybe 15 minutes for a larger transformer.

Peter Reed,
via email.

Digital TV farce

Like many of your readers, I've been following the "progress" of Digital TV broadcasting, albeit with the somewhat jaundiced eye of someone from the *other* side of the TV lens.

Over the years, I have been a somewhat harsh critic of "Those Who Would Reform Our TV Systems" (basically from the "Curmudgeon-Who-Actually-Knows" viewpoint), mostly irritated by the grossly over-stated benefits of adopting various proposals, combined with the invariably grossly understated cost and inconvenience of adopting them! The worst example of this would have to be the BMAC system.

When the first Digital TV transmissions were demonstrated about 10 years ago, I thought: "At last! Something with *real benefits* for both the broadcaster and end user!"

Well, it took the various broadcasting authorities a while but they've managed the almost impossible feat of messing up the introduction of Terrestrial Digital Television. To my mind, what should have happened is that all the current analog channels would have been simulcast on a special narrow band of frequencies, perhaps at the top of the existing UHF band.

Think of the advantages: because of the narrow bandwidth, you could use a low-cost, compact, highly sensitive and highly directional UHF antenna.

Instead, we have this absurd idea of fitting them in among existing TV channels, both VHF and UHF. "But," they said, "you can use your *existing* antenna!"

As we now know, this is mostly rubbish. I know quite a few people with digital set-top boxes and the only ones who could get all the digital channels straight off are the ones who get perfect analog reception anyway! I got some of them to work by resorting to the old installers' trick of carrying an antenna around the outside of the house, looking for a "sweet spot". But this was still an extremely tedious procedure, because you had to locate what seemed like a likely spot with an ordinary TV set first and then see if the digital tuner would tune in ALL the channels there, and quite often it wouldn't.

So in the vast majority of cases, it pretty much looks like you're not going to get Digital TV without a revamped antenna installation anyway and so the UHF narrow band option would have cost about the same and given far better results.

No doubt you've seen the recent news stories that Berlin has now switched off its analog TV transmissions and this is being touted as a triumph for Digital TV and the technosavvy of the Germans and so on.

Actually, the vast majority of Berliners are still watching analog TV, now delivered by cable! The reality is that about 83% of Berlin households are connected to cable TV which carries both free-to-air and cable channels. There are some digital cable services but most of them are analog, similar to Foxtel here. Most of the people without access to cable are welfare recipients, so the government has provided such people with set-top boxes for free or heavily subsidised.

I would love to know how this is working in practice, since a lot of "low rent" viewers tend to use "rabbit ear" type antennas, which simply will not work with digital transmissions. Most people would rather a "ghosty" picture than no picture but Digital doesn't give you that option!

There are a lot of other aspects that get glossed over too. Very few households these days have just the one TV set and many have more than one VCR. Each one of these is going to need a set-top box and again, most people only have a proper antenna connection in the lounge, relying on pop-up antennas for bedroom sets and so on, so there are more sets that will be effectively put out of action.

I also think that digital set-top boxes are still ludicrously overpriced, considering what's in them. I can see in a few years' time that the average TV set will simply have a standard antenna socket and an ordinary VHF/UHF tuner module with a separate Digital IF and decoder section. There's not going to be any "revolution" in viewer habits; people who just want an el-cheapo no-frills TV from K-Mart will still be able to get one but capable of receiving Digital TV.

Keith Walters,
via email.

A long-overdue kick-along for digital TV?

A US appeals court has recently upheld federal regulations requiring television set manufacturers to install tuners that can receive high-quality digital broadcast signals in new sets

starting next summer. The Federal Communications Commission in August 2002 ordered that digital tuners be included in new sets as part of an effort to jump-start the lagging transition to digital television, targeted for completion by 2007 but likely to be delayed.

The Consumer Electronics Association, which represents manufacturers such as Sony and LG Electronics which owns Zenith, had challenged the rules, arguing that the FCC lacked the authority to impose such a requirement and that the order was arbitrary and capricious.

LG might own the Zenith brand-name but there hasn't been domestic (US) TV manufacture in a many years since the Japanese and Taiwanese wiped them out. No wonder the courts don't give a hoot if it inconveniences the manufacturers and impacts their profits.

The interesting thing is that by making it compulsory and due to the size of the US market, they will be making digital TVs by the millions. That will bring the cost down to where any other standard will be infeasible to start manufacture and we'll probably all end up using these sets worldwide.

I don't think the small digital take-up in Australia will hold back the flood of a cheaper standard and the providers (studios) will need to be compatible with overseas formats, preferably without such hacks as standards converters.

I'm assuming that our standard *is* different from the US one? That was the way it was going last time I paid attention. Well, that's my opinion anyway, always supposing they don't try making region-locked TVs and add region coding to prevent grey-marketing.

Congratulations on the excellent LED torch in the November issue; I hope there's a kit available soon from someone. Unfortunately, also a big HISS-BOO at the valve preamp. Even if anyone is sad enough to build it, it will have been a sorry waste of paper and ink, in my opinion.

Paul Turner,
Burwood, NSW.

Multi-element TV antennas: are they a con?

On the 25th October, parts of Sydney were hit by a massive hailstorm. I live out near Penrith and we copped the full brunt of it.

Fortunately, my house sustained only minor damage, the worst being to the TV antenna. This is what's interesting. Because we're a long way from the Artarmon transmitters, something other than the usual "suburban" installation is needed. But rather than putting up a huge mast, I decided to try using a "deep fringe" antenna, on an ordinary mast. This worked pretty well except for snowy reception on SBS.

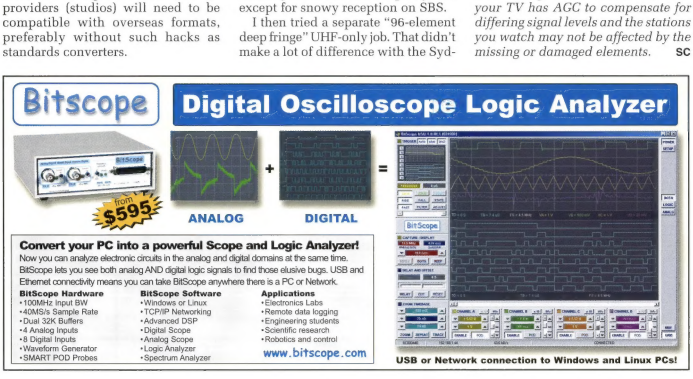
I then tried a separate "96-element deep fringe" UHF-only job. That didn't make a lot of difference with the Sydney SBS transmitter but I found that by pointing it at Wollongong, I could get a much better version of SBS, plus quite usable reception of their UHF versions of 2,7,9 & 10.

Well, the interesting thing is that after the storm, the antennas were a bit of a mess! One of the UHF antenna's two back-screens were on the ground, along with most of its directors. The VHF antenna had lost its two big VHF I reflector rods and most of its other elements were twisted around like a tornado had hit it. But when I tried turning on the TV, I found that it worked almost as well as it did before!

So what is all that fancy-looking ironmongery for? It smells to me like somebody's just making a fairly ordinary antenna and "decorating" it with a lot of fiddly bits that don't do very little! But how do you tell a "real" antenna from a fake, without actually putting it up on mast?

Adrian Kerwitz,
via email.

Comment: without comprehensive test equipment, a shielded anechoic (to RF) room or an antenna test facility, it is impossible to fully characterise any antenna, particularly one that is designed to cover a wide frequency range. The fact that your setup shows little change is no indication, since your TV has AGC to compensate for differing signal levels and the stations you watch may not be affected by the missing or damaged elements. **SC**



By JIM ROWE

Artist's impression of a NOAA weather satellite (Courtesy Lockheed-Martin Missiles & Space).

What you need to receive weather satellite images

Interested in receiving the images broadcast by orbiting weather satellites? It's now easier than ever, as long as you have a reasonably up-to-date PC fitted with a sound card. In this article, we explain how weather satellites work and tell you what you'll need to receive their images. And elsewhere in this issue, we describe a weather satellite receiver that you can build yourself.

YES, IT'S TRUE that you can see weather satellite images (or computer enhanced graphics derived from them) on the TV evening news and you can also download images of "special weather events" like cyclones from sites on the Internet. But there's nothing quite like the satisfaction of receiving them yourself directly from the satellites, as many radio amateurs and other enthusiasts have been doing for decades. And as it happens, this is now a lot easier to do than it has ever been before.

Only a few years ago, you not only needed a suitable receiver and antenna to receive the weather satellite signals but a special decoder box as well, before the signals could be displayed on a PC (using a specially written program). But now, providing your PC is reasonably up to date and has a decent sound card, the decoder box is no longer needed. Instead, you simply feed the audio signals from the receiver into your sound card and record them on your hard disc.

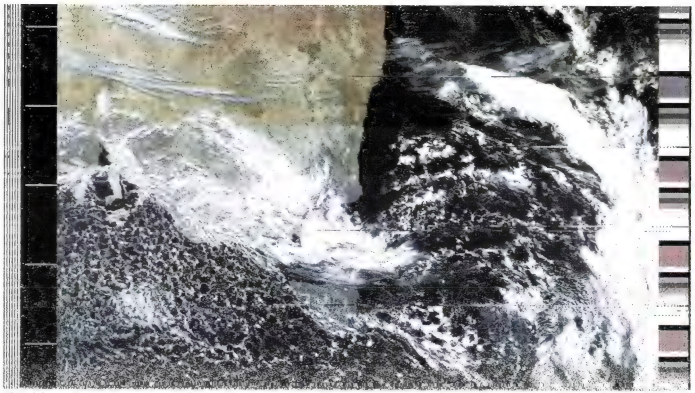
That done, they can be decoded and displayed in one operation, using software that's freely available on the Internet.

So if you'd like to try your hand at receiving weather satellite signals, it's now all fairly straightforward and can be done at low cost (provided you already have a PC).

In this article, we'll give you a quick introduction to weather satellites, describe how they work and describe the kind of receiver, antenna and masthead amplifier you'll need to receive their signals. We'll also discuss the kind of PC you'll need and tell you about some of the software that's available to both track the weather satellites (so that you can be prepared when one comes within range) and then decode their signals after you've received them.

About weather satellites

Weather satellites have been orbiting the Earth for over 43 years now, providing valuable information on the world's weather and other envi-



This false-colour picture from NOAA17 shows extensive cloud cover over the southeastern corner of Australia. The vertical band at far left shows the sync pulses, while the adjacent vertical black band carries the minute markers (this picture was received over a period of about five minutes). The vertical band at far right represents undecoded telemetry data, which conveys the status of various systems on-board the satellite.

ronmental events on a 24-hour basis. The first of these satellites was Tiros 1, launched by NASA for the US National Oceanic and Atmospheric Administration (NOAA) in April 1960. Since then, there has been not only a continuous series of NOAA satellites but also many broadly similar satellites launched by the former USSR, Japan, India and the People's Republic of China.

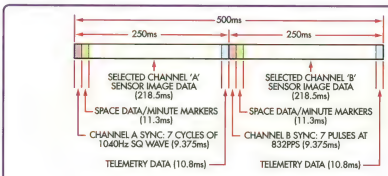
So you mightn't have been aware of them but at any time in the last few decades there have been quite a number of weather satellites orbiting above us and sending down a constant stream of images and other meteorological data.

There are still quite a few satellites in orbit, although some of them (like the Russian Meteors) seem to have reached the end of their operating life and are no longer sending down any pictures. But there are still at least two fully operating NOAA satellites, for example, providing weather images at least twice and sometimes three or four times a day virtually anywhere in the world.

By the way, there are two rather different types of weather satellite. One type are in equatorial orbits (ie, around the Equator) at an altitude of about 35,800km, so they rotate in synchronism with the Earth itself and are therefore described as "geostationary". Each of these satellites constantly views a fixed "disc" of the Earth, with its centre point on the equator directly below it.

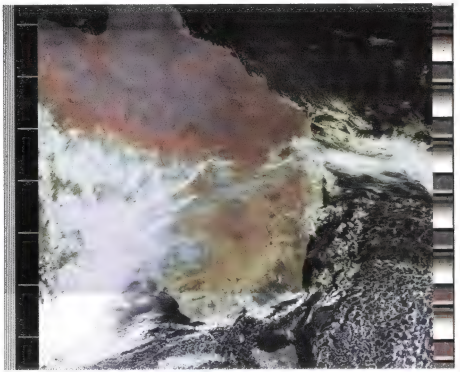
Signals from a geostationary satellite can be received continuously from anywhere inside its field of view. However, receiving their signals isn't easy because they only transmit in the UHF S-band (typically at 1.691GHz) and the signals are quite weak because they're coming from so far away. You need a fairly large dish antenna with a low noise down-converter (LNC) just for a start.

The other kind of weather satellites are in close to polar orbits (ie, passing over the poles) and orbit at a much lower altitude – ie, around 850km. In other words, they're "Low-Earth Orbiting" or "LEO" satellites and each circles the Earth many times a day and passes over (or at least near)



NOAA WEATHER SATELLITES: APT VIDEO LINE FORMAT

Fig.1: an APT transmission line starts with a sync pulse burst. This is followed by an 11.3ms section allocated to "space data" and minute markers, then a 218.5ms section with 909 pixels of image data from the Channel A sensor, and then 10.8ms of telemetry data. This 250ms-long data format is then repeated for the Channel B sensor.



This is another false colour picture from NOAA17, this time received over a period of about seven minutes and showing a large part of eastern Australia extending from the Gulf of Carpentaria down to Tasmania. The sudden change in the picture towards the bottom is a result of turning up the RF gain control on the receiver at this point during signal reception.

any particular point a couple of times a day.

The NOAA satellites are of this type and typically orbit the Earth about 14.1 times a day, or about once every 102 minutes. For example, the NOAA17 satellite currently passes over New Zealand and Australia a number of times during each morning, while the NOAA12 satellite passes over a number of times in the late afternoon or early evening.

Since these satellites "precess", or slowly move around the Earth as they orbit, their "passes" don't follow the same path every time. However, there is usually at least one pass (and sometimes two or three passes) by each satellite that can be received each day, to provide interesting weather pictures.

Another big bonus with the LEO satellites is that they not only transmit weather images in the UHF band (usually on 1.698GHz or 1.707GHz) but also in the VHF band on frequencies such as 137.50MHz and 137.62MHz. And although you need a steerable dish and LNC to track the satellites and receive their UHF signals, the VHF signals are much easier to receive. For VHF, all you need is a fixed antenna with a roughly hemispherical reception characteristic, plus a masthead amplifier and a suitable VHF receiver.

So the polar orbiting LEO weather satellites are of much greater interest to amateur weather satellite enthusiasts, because their VHF signals are a lot easier to receive. And NOAA's satellites 12, 15 and 17 are of particular interest at present, because they're the ones that are currently in operation.

The NOAA satellites

The latest generation of NOAA satellites are fairly large "birds", powered from a large solar cell array which is attached to one end (see artist's drawing). They are equipped with quite a range of scanning and sensing subsystems, including microwave and IR sounders, an alpha particle sensor and the main source of meteorological images: the Advanced Very High Resolution Radiometer/3, or "AVHRR/3" for short.

The data from these sensors is transmitted back to Earth (along with housekeeping telemetry data) via a number of communications links. In fact, each NOAA satellite has no less than 14 antennas, nine transmitters and various receivers (for receiving command data).

The AVHRR/3 is mounted at the opposite end of the satellite from the solar array. It is a continuous imager, which uses a rotating mirror scanning system to scan the path beneath the orbiting satellite in "lines" which are perpendicular to the path and stretching from the horizon on one side to the other.

The scanning mirror rotates at 120RPM, giving 120 lines per minute – chosen because as the satellite moves in its orbit, this provides the vertical deflection, so each scanning line butts against the last for contiguous scanning. The radiometer's sensors have quite a small field of view (1.3 x 1.3 milliradians, or about .075° x .075°) and the sensor outputs are sampled on the spacecraft at a rate of 39.936kHz, so there are essentially 2048 samples per sensor per scanned line.

There are a total of six sensors in the AVHRR/3 radiometer, three scanning at visible wavelengths near the infrared and three at thermal IR wavelengths. The outputs from any five of these sensors can be transmitted back to Earth at any time on the UHF (1.7GHz) channel. However, the satellite's APT (automatic picture transmission) signals provided on VHF (137.5MHz or 137.62MHz consist of down-sampled versions of the signals from two of the AVHRR/3 sensors, selected by commands uplinked from NOAA's control centres.

During the part of each satellite's orbit that is in daylight, each APT line contains data from one visible light sensor and one IR sensor. By contrast, at night the visible light data is replaced by data from a second IR sensor to provide more useful information.

The down-sampled APT data derived from the two selected AVHRR/3 sensors is converted back to analog form and then used to amplitude modulate a 2400Hz audio subcarrier, together with synchronisation and timing pulses and other telemetry data. The 2400Hz subcarrier is then frequency modulated onto the VHF carrier signal, for transmission down to Earth via a 5W FM transmitter and helical antenna.

APT signal format

Fig.1 shows the basic format of the signals conveyed in one APT transmission line (lasting 500ms). The line starts with a sync pulse burst of seven

cycles of a 1040Hz square wave. This is then followed by an 11.3ms section allocated to "space data" and minute markers, then a 218.5ms section with 909 pixels of image data from the channel A sensor, and finally 10.8ms of telemetry data.

The second half then starts with a second sync pulse burst of seven pulses at 832Hz, followed by a second space data and minute marker section of 11.3ms. Then comes another 218.5ms section with 909 pixels of image data from the channel B sensor and finally another 10.8ms of telemetry data.

It's this format that gives the signal a characteristic "tick-tock" sound when you listen to the received 2400Hz audio via a speaker or earphones.

Receiving antenna

The VHF APT signals from NOAA satellites are strong enough not to require a high-gain tracking antenna. Instead, a low-gain fixed antenna can be used, although it does need to have a hemispherical or "flattened hemispherical" reception characteristic so that it picks up the signals with much the same sensitivity as the satellite passes over.

Note that because the signals are transmitted from the satellite via a helical antenna, they are also right-hand circularly polarised. This means that the antenna must also be able to pick up signals with this type of polarisation.

There are three main types of receiving antenna which meet these requirements: (1) the crossed-dipole or "turnstile" antenna (either alone or combined with a reflector to become a turnstile/reflector); (2) the Lindenblad antenna; and (3) the quadrifilar helix antenna or "QFHA". Of these, the QFHA probably gives the best performance but is not easy to build because it's essentially a truncated double helix.

The Lindenblad gives reasonable performance but is still fairly difficult to make because it consists of four dipoles in a square array, with each dipole tilted at 30°. It also doesn't perform well unless it's mounted very high off the ground and well away from metal roofing.

In fact, the author built and tested a Lindenblad antenna for the receiver described elsewhere in this issue but after a lot of frustration, I finally scrapped it and built a turnstile/reflector instead. This was quite easy to make and also gives surprisingly good reception at my location.

A crossed-dipole or "turnstile" antenna coupled to a masthead amplifier are all that are required to "pull in" the signals from the NOAA satellites. Articles describing how to build these items will be published in SILICON CHIP in the next few months.

Now although the VHF NOAA signals are strong enough to be received using this type of fixed antenna, they're still pretty weak. After all they're coming from a 5W transmitter which is still more than 800km away even when the satellite is passing directly overhead. The transmitting antenna is also propagating this power in a solid angle of 63°, so by the time it does reach the ground below, the effective path loss is quite high.

From a practical point of view, this means that most VHF receivers simply aren't sensitive enough and don't have a good enough noise figure to give good reception of the weather satellite signals by themselves. In short, you also need a low-noise masthead preamp, to boost the signals as close to the antenna as possible – and certainly before they have to pass down through any significant length of coaxial cable to the receiver (which introduces losses).

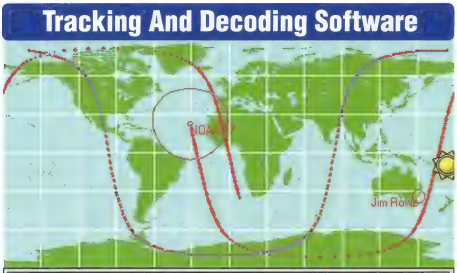
So as well as describing an easy-to-build turnstile/reflector antenna in coming months, we'll also be describing a suitable masthead preamp. Stay tuned!

The receiver

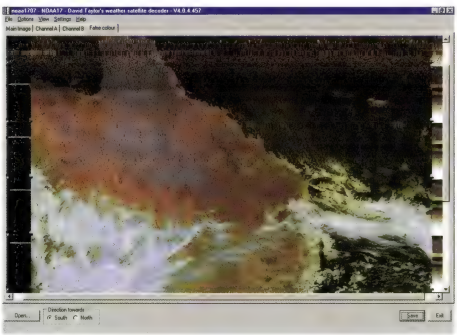
Since the NOAA signals are in the 137MHz VHF band and use FM, you'd expect that almost any VHF communications receiver or scanner would be suitable for receiving them. However, while it's true that you can receive them reasonably well with some receivers, the results are often disappointing.

That's mainly because the 2400Hz satellite subcarrier signal is modulated with an FM deviation of ±17kHz, so it has a bandwidth of about ±25kHz. This bandwidth is quite a bit wider than that used for narrow-band VHF FM communications but at the same time, it's much narrower than that used by broadcast FM stations. So a VHF scanner or communications receiver can't be set to its narrow bandwidth, because this is too narrow to receive the signals without severe distortion. Instead it must be set to WFM (wide-band FM), even though this gives a relatively low audio output level and often a fairly poor signal-to-noise ratio.

The ideal type of FM receiver to use



WinOrbit 3.6 is a "predictive" freeware satellite tracking program that can be downloaded from www.amsat.org/amsat/ftp/software. This readout, taken over a 2-hour period, shows the path and current location of NOAA17, with the large circle indicating the satellite's current field of view. The readout also indicates the dark and sunlit areas of the Earth, as indicated by the purple/red plot and the Sun symbol (ie, all areas in the middle of the "U" were in darkness when this plot was made). The program can predict the time of the next useful pass of the nominated satellite for a given location and shows lots of other data as well.



SatSignal V4.04 is a freeware APT decoder that works quite well. You can download it from www.satellitescience.com or from www.satsignal.net.

for the APT signals is one with a bandwidth of about ±30kHz, or not much more. There are specially designed weather satellite receivers with this bandwidth available commercially but they're fairly expensive. Because of this, we've developed a small 2-channel VHF FM receiver which has a bandwidth of about ±35kHz and is therefore quite suitable for receiving the APT signals.

This receiver is described in this issue in a separate article, so that you can build your own at a reasonable cost.

As you've probably guessed already, it's the 2400Hz subcarrier "audio" signal from the receiver that contains the APT information as amplitude modulation. As a result, it's this signal which is fed into your PC via the sound card, to be initially stored on the hard disk and then decoded and displayed using the appropriate software.

PC requirements

You don't need a particularly hot PC to record and decode the APT signals. Almost any reasonably up-to-date machine will do, as long as it's running Windows 98SE or better, has a sound card and also has a reasonably fast and capacious hard disk so you can record mono audio signals sampled at 11.025kHz (16 bits). Most Pentium II, III and IV machines should be quite suitable, as should many of the machines using Celeron and Athlon processors.

Of course, your PC also needs to have a modem and an Internet connection, so you can get on the Internet to download the software you'll need for both satellite tracking and weather image decoding. You'll also need the Internet connection to download the orbit update information for the satellites you want to track.

Tracking software

Because the polar-orbiting satellites move in very well defined orbits, the position of each one can be calculated at any time based on the so-called Keplerian elements (orbit definition parameters) for that satellite. This is done by tracking software, which can also predict when that satellite will pass within your antenna's field of view, once it knows your longitude and latitude. This calculation is done completely "off line"; you don't need your weather satellite receiver to be working.

There are quite a few freeware and shareware satellite tracking programs available on the Internet. We tested and can recommend WinOrbit 3.6, written by American radio amateur Carl Gregory, K8CG. Once you provide it with the orbital information on the satellites you want to track, it can not only plot their positions at any time on a world map but also predict the next useful pass of any nominated satellite together with the local time, the satellite's range and elevation and so on.

WinOrbit 3.6 is freeware, and you

Useful Websites

If you'd like to get some more information on weather satellites, or to download some satellite tracking or decoding software, here are some useful websites and documents:

www.amsat.org

http://celestrak.com/NORAD/elements/

www.david-taylor.myby.co.uk/software/

www.drig.com

www.geocities.com/SiliconValley/2504/wx.htm

www.noaa.gov

www2.ncdc.noaa.gov

www.oso.noaa.gov

www.riglib.demon.co.uk/index.htm

www.satellitescience.com

www.satsignal.net

http://sattrackhouston.com

www.telecable.es/personales/ealbcu/kepsen.htm

www.time-step.com/apt

can download it as a single zipped file (WINORB36.ZIP – 478KB) from various sites, including **www.amsat.org/amsat/ftp/software**. However, we plan to make a copy available on the SILICON CHIP website, so look for it there first.

Two other popular satellite tracking programs are L. Hamilton's "Footprint V2.08" which can be downloaded from **www.riglib.demon.co.uk/footprint.htm** and "WXTrack V3.4.0" which is written by David Taylor of Edinburgh, Scotland and can be downloaded from his website at **www.satsignal.net**.

Which ever program you decide to use, you'll need to provide it with the tracking data for the satellites you want it to track (ie, their Keplerian elements). This tracking data can be downloaded as a text file from various Internet sites. For example, you can get the data for the NOAA satellites from **http://celestrak.com/NORAD/elements** – it comes as a text file called "noaa.txt". This is then simply renamed with a "2li" extension instead of "txt", after which it can be used by the tracking program.

Using the tracking program, you'll be able to find out when the satellite you're interested in will next be in range. You'll then be able to receive its signal at the expected time and record it on your PC's hard disk using an audio recording program. You can use CoolEdit (which can be downloaded from the Internet), for example, or Creative Recorder which comes with most Sound Blaster audio cards.

By the way, most weather satellite decoding programs seem to want the signals recorded as WAV files, in mono (left channel), with 16-bit resolution and a sampling rate of 11.025kHz. So that's the recording format to use and it's much more economical when it comes to disk space than recording in 44.1kHz stereo.

APT decoding software

Once you have the signals recorded on your hard disk, you can fire up the decoding program and process them to produce the actual images. So if you don't have a decoding program as yet, the next step is to download one of the freeware or shareware decoders available on the Internet.

There are quite a few weather satellite decoding programs available for free downloading; eg, from sites such as **www.satellitescience.com**. One of the most popular programs is WXSAT 2.59e, written by Christian Bock. It's free for schools and private/amateur use and has good documentation. It's also fairly easy to use, although sometimes it seems to have trouble decoding signals where the subcarrier has been Doppler shifted in frequency.

After testing several programs, we eventually settled on SatSignal V4.04, written by David Taylor. You can download this program from www.satellitescience.com or directly from David Taylor's own website at **www.satsignal.net**. All of the weather satellite images shown here were decoded using SatSignal V4.04, incidentally.

By now, you should have a good understanding of how weather satellites work and how you can receive images from them using a suitable receiver, a PC and freeware software from the Internet. If we've whetted your appetite, the next step is to take a look at the 2-Channel VHF Weather Satellite Receiver described elsewhere in this issue of SILICON CHIP. It's easy to build and will have you receiving your own weather satellite pictures in next to no time. **SC**

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Trigger your car's self-diagnostic fault codes

SELF DIAGNOSTICS PLUG

by Julian Edgar

For many years cars have logged any faults that occur in their engine management system. The most advanced systems record not only the fault, but also engine operating conditions at the time the fault occurred.

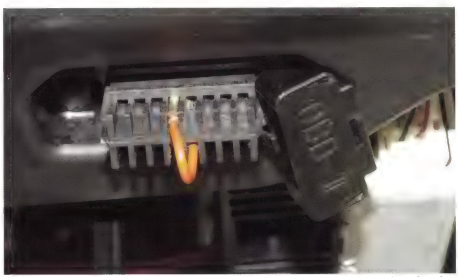
These systems normally need a dedicated data reader (eg a manufacturer's own service tool) to read them. But nearly every car has a simpler way of accessing these codes. By linking two pins in the diagnostics plug, most cars can be made to flash their diagnostic codes on the dashboard Check Engine light.

For example, two short flashes followed by four longer flashes might indicate the fault code number '24', and finding out what '24' means is as simple as looking up a service manual. Even basic manuals have these codes listed.

Cars sold or built in the United States after January 1, 1996, use what's called an OBDII diagnostics system. 'OBD' stands for Onboard Diagnostics and represents a standard that allows certain engine data to be downloaded, including fault codes.

(Well it's kind of a standard – see the 'OBD – Oh Bloody Difficult?' breakout box.)

The influence of the huge US market is such that many cars sold in other countries also have an OBDII socket



The plug inserted into an OBDII port. In this car the socket is located under the steering column.

The OBDII plug comes with the pins and shell separate. In this application only two pins need to be used.

Here the wire link between the two pins can be clearly seen. The connections to the pins can be made by soldering or crimping

The plug inserted into an OBDII port. In this car the socket is located under the steering column.

fitted. Many of the pins in the OBDII socket aren't used by the standard, so most manufacturers also mount in the same plug the pins that can be bridged to trigger the trouble codes.

So, easy, huh? Just dive under the dash, find the OBDII plug, check in a workshop manual which pins need to be bridged and..... er....

Yes, it's not much fun trying to insert the end of an unbent paper clip into the socket pins while lying upside-down under the dash, is it?

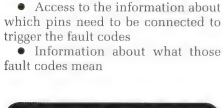
In fact, it would be damn easy to bridge the wrong pins and potentially cause all sorts of catastrophic damage...

And that's where this very simple idea comes in. Jaycar Electronics has recently started selling an OBDII compatible plug. Which means that rather than fiddling with a wire link, all that you need to do is permanently wire the connection in place inside the plug, and when you want to trigger the fault codes, simply plug it into the socket.

Whoa!

But let's take a step back. For this system of easily triggering fault codes to work on your car you need three things:

- A car with on an OBDII socket
- Access to the information about which pins need to be connected to trigger the fault codes
- Information about what those fault codes mean



The OBDII connector is a 16-pin design which uses these pin placements.

As mentioned, the last one is pretty easy – even basic workshop manuals list the fault codes, and the factory workshop manual will normally go into pages of detail on each code. Good factory workshop manuals will also help you out with the second requirement – knowing which pins to bridge to trigger the self-diagnostics. These manuals are available at the

"OBD" – Oh Bloody Difficult?

Of course the primary function of the OBDII socket is to allow the transfer of data. In fact, commercially available readers exist that can display live engine operating information – in addition to fault codes – on a Windows CE or Palm handheld, or a PC.

We've also seen kits for the adaptors that will take the data out of the OBDII port and allow you to display it in all kinds of great ways.

So why aren't we covering just such a project here?

There are two main reasons.

Firstly, there is not just one OBDII standard, but rather there are four different standards. Many of the readers can work with only one standard, although it must be said, just a few will cope with all four.

But for us here in Australia, the major difficulty is that many of our cars don't have OBDII compatibility. We can just imagine how happy you'd all be if we covered a kit and when you built it, you found it wouldn't work with your car, despite the fact that it had an OBDII port. And despite the fact, even, that it had 'OBDII' written on it and it said in the manual that it was OBDII compatible...

It is a fact of life that many of the cars sold in Australia aren't fully compatible with the OBDII standard.

It's not required that cars sold here are OBDII compliant and many manufacturers don't bother doing so. In the case of the author's 1998 Lexus LS400, for example, despite the factory workshop manual clearly claiming that the car was OBDII compliant, and despite the fact that it had OBDII written on the cover of the (OBDII) socket, a commercial OBDII data reader fails to work with the car.

Why? The software inside the ECU is not compatible with OBDII!

In fact, in our experience there is a range of Australian-delivered cars that transmit at least some OBDII data (late model Holden, Subaru, Mazda, Honda, Porsche) and also a range of cars that do not (Falcon, Peugeot, Lexus).

That's the total sample that so far we've looked at – many more cars will be in one category or the other. There is simply no way of telling whether the car is OBDII compliant without plugging in a data reader and seeing if it works.

That Mazda supports it and the Ford Falcon does not is even more confusing, since the companies now share much of their engine management technology.

Note also that service departments have no idea which of their cars are OBDII compliant and which aren't. They just plug in their factory service tool and away they go.

In the future it may be that more cars in Australia will become OBDII compliant (although there is a mooted OBDIII standard which might throw another spanner in the works).

If OBDII – or a similar standard – is mandated in Australia, we will then be very interested in doing a data reader project. Because when the OBDII data stream is actually working, it's fascinating stuff indeed.

In most cars the Check Engine light will flash out the fault codes. However, in the case of the Lexus shown here, the actual fault code number is displayed.

service departments of car dealers and also, in many cases, in the libraries at TAFE colleges where automotives is taught.

But the first step is to see if your car has an OBDII socket. As mentioned, that will only be the case if the car was made after January 1, 1996. The socket is legally required to be located inside the cabin, and must be able to be accessed without tools. (In practical terms, a small screwdriver may be needed to lift an interior trim panel.) Start off by looking under the dash, behind the ashtray, under the glovebox, under the trim panel beneath the handbrake and in similar places. The 16-pin socket has a characteristic shape (wider at the top than the bottom) and may be protected by a push-on cover.

Once you've found it, see if you can get the info on the pins that need to be bridged – perhaps start with the service department of the local new car dealer.

Building It

As one of the simplest projects we've ever covered, this part shouldn't take you long. The Jaycar plug (PP0720) is provided with the pins and plug body - you need to insert the pins into the plug to form the assembled item.

To put the plug together it's just a case of separating two pins from the strip to which they're tied, soldering or crimping a short insulated bridging wire between them and inserting them into the right holes from the rear of the plug (the pins will click into place only if inserted with the correct orientation).

Make sure that you view the plug from the rear when selecting the correct pins, as all workshop manuals show the view looking into the socket!

Using It

In the case of the author's Lexus LS400, the workshop manual indicates that fault code triggering will occur if pins 13 and 4 are bridged. In this car the codes are displayed in numeric form on the multifunction LCD dash display – no flashes need to be counted. So after the plug was wired it was just a case of plugging it into the OBDII socket and then following the workshop manual's instructions to display the fault codes on the dashboard display.

After you've finished doing the fault diagnosis, it's easy to keep the plug in the glovebox. **SC**

Auterra (www.auterraweb.com) make an excellent general-purpose OBDII reader that works with Palm OS devices. Here the ignition timing advance and airflow meter mass flow are being read live from a Holden Astra Turbo on a Treo 270 smartphone. However, many Australian-delivered cars are not OBDII compatible, despite often having an OBDII port.

The 1999 Hyundai Accent

Don't think that you'll find an OBDII connector in just expensive cars. The 1999 Hyundai Accent has an OBDII socket with its pins having the following functions:

Pin 1 – TCM
Pin 4 – Ground
Pin 7 – Engine
Pin 8 – ABS
Pin 12 – Airbag
Pin 14 – Vehicle Speed
Pin 15 – L-wire
Pin 16 – Battery +

This is straight out of the workshop manual – no, we don't know what 'TCM' is either. But we do know from the manual that triggering the fault codes requires these steps:

(1). Turn on ignition (do not start car)
(2). Ground the L-wire in the data link connector for 2.5 – 7 seconds
(3). If no fault is present, '4444' will be flashed on the Malfunction Indicator Light (MIL is another name for Check Engine Light)
(4). Each codes repeats until the L-wire is again grounded, whereupon the next code appears
(5). '3333' indicates the end of code outputs

So for the Excel, Pin 15 needs to be wired to Pin 4 in the OBD plug.

Then just insert the plug for about five seconds to start the fault diagnosis process, with up to 21 fault codes then available.

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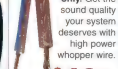

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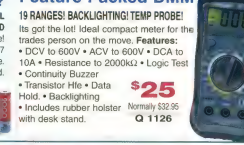

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VHF Receiver For Weather Satellites

Here's a compact, low-cost 2-channel VHF FM receiver for pulling in weather satellite signals in the 137-138MHz band. It has good sensitivity and adjustable RF gain, combined with the correct bandwidth for weather satellite APT signals. You can also operate it from either a plugpack or a 12V battery, for greater flexibility.

By JIM ROWE

WHILE YOU CAN use a standard VHF scanner or communications receiver to pick up weather satellite signals, the results are often disappointing. The reason for this is that most scanners and communications receivers only provide a choice of two bandwidth settings for VHF FM reception: "narrow" and "wide". The narrow setting gives a bandwidth of ±15kHz or less, which is fine for NBFM reception. However, it is too narrow for undistorted reception of the weather satellite signals which need a bandwidth of at least ±25kHz.

By contrast, the wide bandwidth setting usually gives a bandwidth of about ±100kHz, so this is the setting that must be used. Unfortunately, this is really too wide for weather satellite signals and, as a result, the demodulated audio level is relatively low. At the same time, the wider reception bandwidth allows more noise through, so the signal-to-noise ratio can become quite poor.

In short, for best results you really need a receiver with an effective bandwidth of ±30kHz, or not much more. This type of specialised VHF receiver is available but they are not very thick on the ground and those that are available are fairly pricey. Hence the motivation for developing the low-cost weather satellite receiver described here.

As you can see from the photos, the receiver is built into a very compact plastic instrument box. All of the circuitry is mounted on a double-sided PC board, so it's quite easy to build. It has switch tuning between two preset frequency channels, for ease of use. There are RF Gain, Audio Muting and Audio Gain controls and the receiver

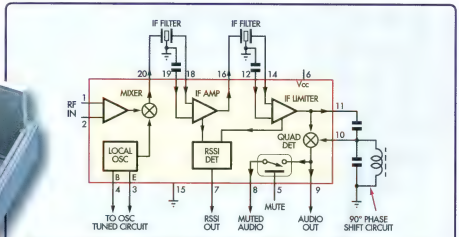


Fig.1: block diagram of the Philips SA605D low-power FM mixer and IF system. It contains a local oscillator (LO) transistor, a balanced mixer, a high gain IF amplifier and IF limiter, a received signal strength (RSSI) detector, an FM quadrature detector and an audio muting circuit.

can drive a small monitor speaker or headphones, as well as providing a line level signal to feed into your PC for recording and decoding.

The sensitivity is quite respectable, at about 0.7μV for 12dB of quieting. At the same time, the effective bandwidth is approximately ±35kHz, which is quite suitable for weather satellite reception.

Bear in mind though that for good reception of these signals, you really need to use a masthead preamp as well. The receiver provides 12V DC at the antenna connector, for "phantom powering" such a preamp. We'll describe a matching preamp in the third of these articles, along with an easy to build turnstile/reflector antenna for 137.5/137.62MHz.

Circuit description

At the heart of the receiver is an SA605D IC, which is described by Philips as a high-performance low-power FM mixer and IF system. As you can see from the block diagram of Fig.1, it contains a local oscillator transistor and balanced mixer, plus a high-gain IF amplifier and IF limiter, a received signal strength (RSSI) detector, an FM quadrature detector and finally an audio muting circuit.

The local oscillator transistor can operate at frequencies up to about 500MHz in an LC circuit, or up to 150MHz with a suitable crystal. The mixer can operate up to 500MHz as well, while the IF amplifier and limiter can operate up to about 25MHz with a combined gain of about 90dB.

That's not bad when you consider it's all packed inside a 20-pin small outline SMD package!

Fig.2 shows the complete circuit details. In this receiver, we're using the SA605D in a fairly conventional single-conversion superhet configuration, with the IF amplifier and limiter working at 5.5MHz. This allows us to take advantage of high selectivity 5.5MHz TV sound IF ceramic filters to provide most of our bandwidth shaping. The two filters in question are CF1 and CF2, which are both Murata SFT5.5MA devices.

As shown in Fig.2, CF1 is connected between the mixer output and the IF amplifier input, while CF2 is connected between the IF amplifier output and the limiter input. The resistors connected to the filter inputs and outputs are mainly for impedance matching, while the 10nF capacitors are for DC blocking. The 90° phase shift required for IC1's quadrature FM detector is provided by coil L4 and its parallel 390pF capacitor, which are tuned to 5.5MHz.

The local oscillator transistor inside IC1 is connected in a Colpitts circuit. This includes coil L3, together with the two 15pF capacitors (which provide the emitter tap) and a 10pF capacitor in series with varicap diode VC3.

Varicap diode VC3 is the receiver's tuning capacitor. Its tuning voltage for each of the two channels is set by 10-turn trimpots VR4 and VR5, with switch S1 selecting between them. We can tune the receiver simply by changing the local oscillator frequency because we only need to tune over a relatively small range (ie, 137.3 - 137.85MHz maximum), which is within the selectivity curve of the "front end" tuned circuits.

Moving now to the front end, this uses a BF998 dual-gate MOSFET (Q1) connected in a standard cascode amplifier configuration. The incoming

Main Features

- Two presettable channels in the 137-138MHz band
- Sensitivity: 0.7μV for 12dB of quieting
- Bandwidth: ±35kHz (approx.)
- Plugpack or battery powered
- Provides 12V DC phantom power to power a masthead amplifier

Parts List

1 PC board, code 06112031, 117 x 102mm (double-sided, not plated through)
1 small instrument case, 140 x 110 x 65mm
2 5.5MHz ceramic filters, Murata SFTRD5M50AF00-B0
2 RCA sockets, 90° PC-mount
1 2.5mm concentric power socket, PC-mount
1 3.5mm stereo headphone jack, PC-mount
1 SPDT miniature toggle switch
3 PC board terminal pins, 1mm diameter
1 TO-220 heatsink, 19 x 18.5 x 9mm
3 small skirted instrument knobs, 15mm diameter
1 coil former, 4.83mm OD with F16 ferrite slug
1 6-pin former base and screening can
1 short length of 0.25mm enamelled copper wire for RFC1
1 F29 ferrite bead (for RFC1)
1 short length of 0.8mm tinned copper wire for L1
1 length of 0.8mm enamelled copper wire for L2, L3
8 4g x 6mm self-tapping screws
1 M3 x 6mm machine screw, M3 nut and lock washer
1 20 x 92mm piece of 0.3mm tinplate for shield

Semiconductors

1 SA605D mixer/IF amplifier/FM detector (IC1)
1 TL072 dual op-amp (IC2)
1 LM386 audio amp (IC3)
1 7812 +12V regulator (REG1)
1 78L05 +5V regulator (REG2)
1 BF998 dual-gate MOSFET (Q1)
1 PN100 NPN transistor (Q2)
1 5.1V 400mW zener diode (ZD1)
1 3mm red LED (LED1)
1 3mm green LED (LED2)
1 ZMV833ATA varicap (VC3)
1 1N4004 1A power diode (D1)

Capacitors

1 2200µF 16V RB electrolytic
1 470µF 25V RB electrolytic
1 330µF 16V RB electrolytic
3 10µF 16V RB electrolytic
1 10µF 35V TAG tantalum
1 470nF MKT metallised polyester
8 100nF multilayer monolithic ceramic
1 47nF MKT metallised polyester
1 22nF MKT metallised polyester
5 10nF multilayer monolithic ceramic
1 4.7nF MKT metallised polyester
8 2.2nF disc ceramic
1 1nF disc ceramic
1 1nF MKT metallised polyester
1 390pF NPO ceramic
2 15pF NPO ceramic
1 10pF NPO ceramic
2 3-10pF trimcaps (VC1, VC2)

Resistors (0.25W 1%)

1 470kΩ	1 1.8kΩ
1 390kΩ	1 1.5kΩ
1 150kΩ	1 1.2kΩ
1 110kΩ	4 1kΩ
1 100kΩ	1 360Ω
1 47kΩ	1 300Ω
1 39kΩ	1 240Ω
3 22kΩ	1 220Ω
2 10kΩ	1 100Ω
1 5.6kΩ	1 47Ω
1 4.7kΩ	1 22Ω
2 2.2kΩ	1 10Ω

Potentiometers

1 50kΩ linear pot, 16mm PC board mount (VR1)
1 25kΩ linear pot, 16mm PC board mount (VR2)
1 50kΩ log pot, 16mm PC board mount (VR3)
2 50kΩ 10-turn trimpots, PC board mount (VR4,VR5)

VHF signals are fed into a tap (for impedance matching) on antenna coil L1, which is tuned to about 137.55MHz using trimmer capacitor VC1. The signal from the top of this tuned circuit is then fed directly to gate 1 of Q1, while gate 2 is bypassed to ground but also fed with an adjustable DC voltage via VR1 for RF gain control.

The amplified VHF signal on Q1's drain is fed to pin 1 of IC1 via a 1nF coupling capacitor. Additional RF selectivity is provided by coil L2 and trimmer capacitor VC2, which are again tuned to about 137.55MHz. The 100Ω resistor and 10µH RF choke form an untuned high-impedance load for Q1.

Notice that as well as being coupled to the tap on L1 via a 2.2nF capacitor, the antenna input is also connected to the +12V supply line via RFC1 and a series 22Ω resistor. As you may have guessed, these components are there to provide "phantom" DC power for the masthead preamp.

At the output end of IC1, we take the demodulated APT signals from the "muted audio" output at pin 8. This allows us to take advantage of the SA605's built-in muting circuit, which works by using comparator stage IC2b to compare IC1's RSSI output from pin 7 (proportional to the logarithm of signal strength) with an adjustable DC control voltage from muting pot VR2. When the RSSI voltage rises above the voltage from VR2, IC2b's output switches high and this is fed to pin 5 of IC1 via a 2.2kΩ series resistor to unmute the audio. ZD1, a 5.1V zener diode, limits the swing on pin 5 of IC1 to less than 6V.

Transistor Q2 and LED1 form a simple signal strength indicator. This also uses the RSSI output from IC1. In operation, the voltage across the 390kΩ resistor and 100nF capacitor rises from about +0.26V under no-signal conditions to about +5V with a very strong input signal. So with Q2 connected as an emitter follower and LED1 in its emitter load, the LED current and brightness are made to vary quite usefully with signal strength.

Low-pass filter

The demodulated APT signal from pin 8 of IC1 is first fed through op amp IC2a, which is configured as an active low-pass filter. This has a turnover frequency of 5kHz and is used for final de-emphasis and noise reduction.

From there, the signal is fed to audio gain control VR3 and then to audio amplifier stage IC3. This is a standard LM386 audio amplifier IC, configured for a gain of about 40 times. Its output is fed to both the monitor speaker socket and to a line output socket for connection to your PC's sound card.

Power supply

Most of the receiver's circuitry operates from +12V, with the exception of IC1 which needs +6V. As a result, the power supply circuitry includes REG1 to provide a regulated and smoothed +12V supply from an external supply such as a 14.5-18V plugpack. This is followed by 5V regulator REG2 which

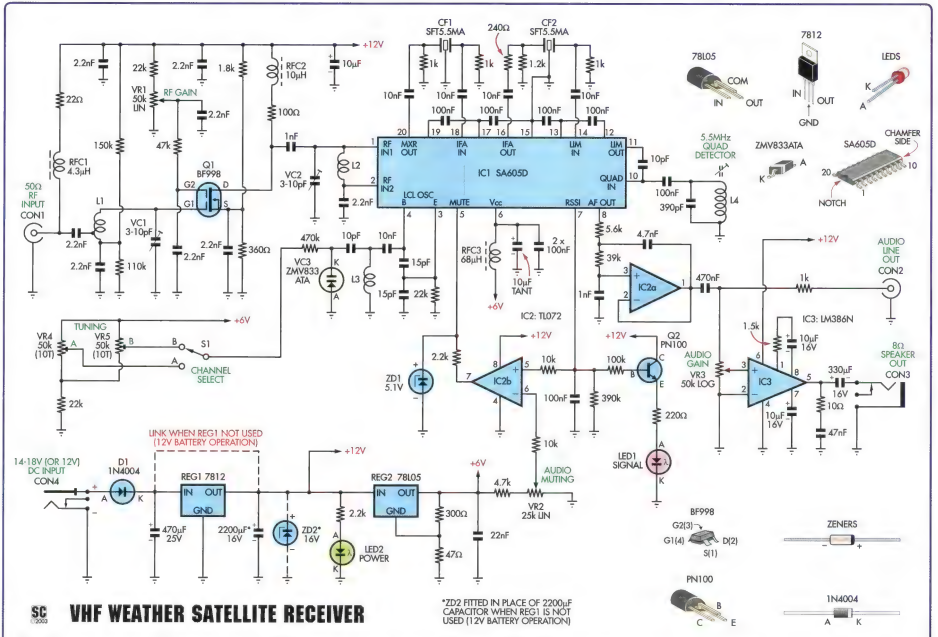
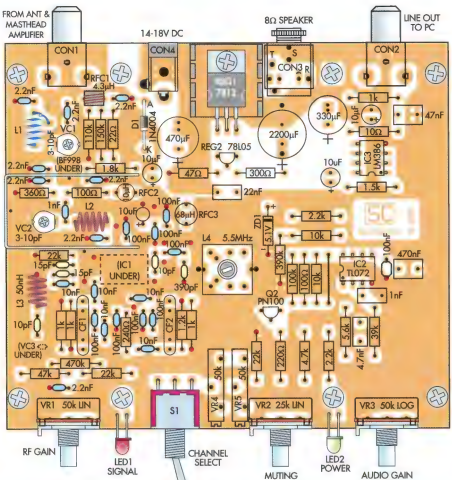


Fig.2: the complete circuit diagram for the VHF Weather Satellite Receiver. Dual-gate MOSFET Q1 functions as an RF amplifier stage with adjustable gain. Its output is fed into IC1 and the demodulated output from IC1 fed to low-pass filter stage IC2 and then to audio output stage IC3. The local oscillator (LO) inside IC1 is tuned using VR4, VR5 and varicap diode VC3.



* TINPLATE SHIELD 20 (H) x 36 x 20mm SOLDERED TO TOP OF BOARD

NOTE: RED DOTS INDICATE COMPONENT LEADS OR WIRES SOLDERED TO BOTH TOP AND BOTTOM COPPER

Fig.3: install the parts on the top of the PC board as shown here. The red dots indicate where component leads and "pin-throughs" have to be soldered on both sides of the PC board. Note that S1 is not directly soldered to the board but is instead connected to three PC stakes using flying leads.

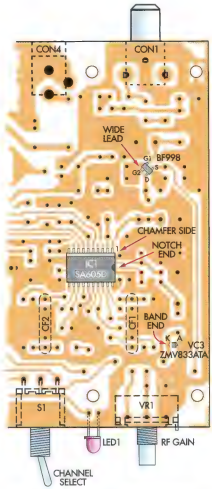


Fig.4: here's how to install the three surface-mount parts (Q1, IC1 & VC3) on the underside of the board. Q1 and VC3 can be held in position using epoxy resin to make soldering easier – see text.

has its output "jacked up" using 300Ω and 47Ω resistors to provide close to +6V for the SA605D (IC1).

Note that if you want to run the receiver from a 12V battery, this can be quite easily done by replacing REG1 with a wire link. In addition, the 2200μF capacitor should be replaced with a 16V zener diode (ZD2) for overvoltage protection.

Construction

Construction is straightforward with virtually all of the parts mounted on a small PC board coded 06112031 (117 x 102mm). The board is double-sided but the top copper pattern is used mainly as a groundplane. This means that the board doesn't need to have plated-through holes but there are quite a few component leads which do have to be soldered on both sides of the board.

There are also a number of "pin-through" wires which have to be soldered to both sides of the PC board around IC1. These connect the earth patterns on both sides of the board and ensure that this high-gain chip operates in a stable manner.

Fig.3 shows the assembly details. As shown, the various input and output connectors are mounted along the rear edge of the board, while the controls and indicator LEDs mount along the front edge. The only component not actually mounted on the board is S1, the channel select toggle switch. This mounts on the front panel, with its three connection lugs wired to PC board terminal pins directly underneath using very short lengths of insulated hookup wire.

Start the assembly by fitting these three terminal pins first (they are the only pins used in the receiver), then fit the project's only wire link, which goes on the righthand side of the board just to the left of IC2. Note that this the link must be insulated, as it carries +12V and passes over groundplane copper.

Next, fit the four connectors CON1-CON4 along the rear edge, followed by the resistors. Table 1 shows the resistor colour codes but it's also a good idea to check each value using a digital multimeter before soldering it in position. All resistors are fitted to the top of the PC board but note that some of them have one lead soldered to the top copper as well as the bottom copper. This is indicated by the red dots on the overlay diagram.

Once the resistors are in, you can fit the "pin-throughs" using some of the resistor lead offcuts. The location of these "pin-throughs" are again indicated by the red dots on the layout

This is the view inside the assembled receiver. Note that a tinplate shield is fitted around L2, VC2 and most of the components in Q1's drain circuit (see text). Note also that the metal bodies of the potentiometers are connected together using tinned copper wire and then connected to the groundplane copper on the PC board.

diagram. Each "pin-through" is fitted by simply passing a wire through the hole in the board, then soldering it on both sides and trimming off the excess lead lengths.

The small ceramic capacitors can now all be installed on the lefthand side of the board. Note that some of these also have their "cold" leads soldered on both sides of the board, as indicated by the red dots. Once they're in, install the MKT capacitors and the electrolytics, making sure that the latter are all correctly orientated.

Now for trimmer capacitors VC1 and VC2. These should be fitted so that their adjustment rotors are connected to earth (this makes it much easier to align the receiver later). It's simply a matter of orientating them on the board as shown in Fig.3.

RF chokes RFC2 and RFC3 are both supplied pre-wound (10µH and 68µH respectively) but RFC1 needs to be wound on an F29 ferrite bead. It's very easy to wind though, because it requires only three turns of 0.25mm enamelled copper wire.

Winding the coils

At this stage, it's a good idea to wind and fit the remaining coils. Table 3 gives the winding details. As shown, L1-L3 are air-cored types, each consisting of five turns of 0.8mm diameter wire wound on a 5mm mandrel. Note, however, that L1 is wound using tinned copper wire, while L2 and L3 are both wound using enamelled copper wire. Don't forget to scrape off the enamel at each end, so they can be soldered to the board pads.

L1-L3 should all be mounted so that their turns are about 2mm above the board. After you've fitted L1, don't forget to fit its "tap" connection lead as well. This can be made from a resistor lead off-cut, since it's very short. It connects to a point 1/3 of a turn up from the "cold" (earthy) end of the coil – ie, just above half-way up the side of the first turn.

The final coil to wind is quad detector coil L4. Unlike the others, this is wound on a 4.83mm OD former with a base and a copper shield can. It's wound from 20 turns of 0.25mm enamelled copper wire and tuned with an F16 ferrite slug.

Table 3: Coil Winding Details

L1	5 TURNS OF 0.8mm TINNED COPPER WIRE, 7mm LONG (WOUND ON 5mm DIAMETER MANDREL). TAP AT 0.3 TURNS. AIR CORED, MOUNTED 2mm ABOVE BOARD
L2	5 TURNS OF 0.8mm ENAMELLED COPPER WIRE, 9mm LONG (WOUND ON 5mm DIAMETER MANDREL) AIR CORED, MOUNTED 2mm ABOVE BOARD
L3	5 TURNS OF 0.8mm ENAMELLED COPPER WIRE, 8mm LONG (WOUND ON 5mm DIAMETER MANDREL) AIR CORED, MOUNTED 2mm ABOVE BOARD
L4	20 TURNS OF 0.25mm ENAMELLED COPPER WIRE, TIGHT WOUND ON 4.83mm FORMER WITH F16 TUNING SLUG AND SHIELD CAN
RFC1	3 TURNS OF 0.5mm ENAMELLED COPPER WIRE WOUND ON AN F29 FERRITE BEAD

Once L4 is wound, fitted to the board and covered with its shield can, you can fit the two ceramic filters CF1 and CF2. These devices can be fitted either way around but make sure that their pins are pushed through the board holes as far as they'll go before you solder them underneath.

The next step is to fashion and fit the small tinplate shield at the location shown in the overlay diagram – ie, around L2, VC2 and most of the components in the drain circuit of Q1. This shield is U-shaped and measures 20mm high, with the front and back "arms" 36mm long and the side section 20mm long. The bottom edges of all three sides are soldered to the board's groundplane in a number of places, to hold it firmly in position and to ensure it stays at earth potential.

Fitting the pots

The two 10-turn trimpots (VR4 and VR5) can now be soldered in position at the front-centre of the board. They can then be followed by the three main control pots, which are all 16mm diameter types. Trim each pot's spindle length to about 9mm before fitting it and make sure you fit each one in its correct position as they are all different. In particular, note that VR1 and VR3 both have a value of 50kΩ but VR1 is a linear pot while VR3 is a log type.

After fitting the pots, it's a good idea to connect their metal shield cans together and then run a lead to the board's top copper to earth them. This is done using a length of tinned copper wire, with a short length of insulated hookup wire then connecting them to the board copper at front right (see photos). Note that it will be necessary to scrape away the passivation from the pot bodies in order to get good solder connections.

Mounting the semiconductors

Now you should be ready to fit the semiconductor devices – or at least those that go on the top of the board. Begin by installing diode D1, 5.1V zener diode ZD1 and transistor Q2.

That done, install regulator REG1 (if you're using it) and its associated heatsink, as shown in Fig.3. These parts are secured to the board using a 6mm-long M3 screw, nut and lockwasher. Note that REG1's centre pin should be soldered on both sides of the board but take care not to touch either of the two large adjacent electrolytic capacitors with the barrel of your soldering iron.

Next, fit regulator REG2, followed by IC2 (TL072) and IC3 (LM386). Note that pin 4 on both these devices should be soldered to the copper on the top of the board as well as the bottom.

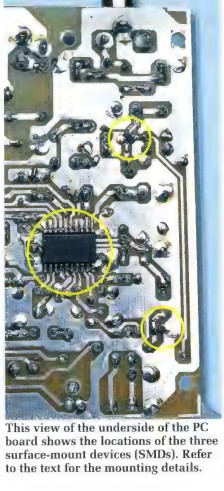
The two LEDs (LED1 & LED2) are both mounted horizontally, so that they later protrude through matching 3mm holes in the front panel. Note that they are both fitted with their cathode leads towards the left. Bend their leads down through 90° about 5mm from the LED bodies, then solder them in position so that the axis of each LED is 5mm above the board.

The final components to fit are the surface-mount parts, which all fit underneath the board – see Fig.4. We're talking here of varicap diode VC3 (ZMV833ATA), the BF998 dual-gate MOSFET (Q1), and the SA605D IC (IC1). The first two in particular are in very tiny packages and need very careful handling.

In fact, these very small devices are not easy to hold in position while you solder them but there is a way around this. The trick is to mix up a small amount of 5-minute epoxy resin cement (Araldite or similar) and then apply an extremely small "dot" of epoxy to the underside of the board at each component position (if you use the end of a resistor or diode lead offcut as the cement applicator, this should apply about the right amount). It's then just a matter of using tweezers to carefully place each component in its correct position over the epoxy "dots", with the correct orientation.

When you're satisfied that they're all located accurately, carefully put the board aside for 10 minutes or so to let the adhesive cure. After this, you can solder their leads to the PC pads without having to worry about them moving.

IC1 can be mounted in the same way



This view of the underside of the PC board shows the locations of the three surface-mount devices (SMDs). Refer to the text for the mounting details.

Table 1: Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
1	470kΩ	yellow violet yellow brown	yellow violet black orange brown
1	390kΩ	orange white yellow brown	orange white black orange brown
1	150kΩ	brown green yellow brown	brown green black orange brown
1	110kΩ	brown brown yellow brown	brown brown black orange brown
1	100kΩ	brown black yellow brown	brown black black orange brown
1	47kΩ	yellow violet orange brown	yellow violet black red brown
1	39kΩ	orange white orange brown	orange white black red brown
3	22kΩ	red red orange brown	red red black red brown
2	10kΩ	brown black orange brown	brown black black red brown
1	5.6kΩ	green blue red brown	green blue black brown brown
1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
2	2.2kΩ	red red red brown	red red black brown brown
1	1.8kΩ	brown grey red brown	brown grey black brown brown
1	1.5kΩ	brown green red brown	brown green black brown brown
1	1.2kΩ	brown red red brown	brown red black brown brown
4	1kΩ	brown black red brown	brown black black brown brown
1	360Ω	orange blue brown brown	orange blue black black brown
1	300Ω	orange black brown brown	orange black black black brown
1	240Ω	red yellow brown brown	red yellow black black brown
1	220Ω	red red brown brown	red red black black brown
1	100Ω	brown black brown brown	brown black black black brown
1	47Ω	yellow violet black brown	yellow violet black gold brown
1	22Ω	red red black brown	red red black gold brown
1	10Ω	brown black black brown	brown black black gold brown

if you like but it's not nearly as small as the other two parts and so isn't as difficult. The main thing to watch out for here is that you don't create solder bridges when you're soldering its leads, as they're spaced at just 1.25mm. Make sure you use a clean fine-tipped soldering iron for this job and work quickly so that you don't overheat either the IC or the copper pads on the board.

After soldering all three SMD devices in place, it's a good idea to inspect them very carefully using a magnifying glass. Check that all joints have been made correctly and that there are no solder bridges.

Final assembly

The completed PC board is housed in a low-profile plastic instrument case. If you purchase a kit, this will probably come with all holes pre-drilled. If not, you will have to drill the front and rear panels yourself using Figs.4 & 5 as drilling templates.

By the way, it's always best to drill a small pilot hole at each location and then carefully enlarge it to size using a tapered reamer. As well as the holes shown, you might also want to drill small "blind" holes in the rear of the front panel to mate with the locating spigots on VR1, VR2 and VR3, and the spigot on the backing washer for toggle switch S1.

Once the panels have been prepared, you can mount switch S1 on the front panel and connect three 30mm lengths of insulated hookup wire to the three pins on the PC board via. That done, the front panel can be mated with the PC board by positioning it on the three pot ferrules and doing up the nuts. The three leads from the PC board pins can then be soldered to the switch lugs.

The rear panel is not attached to the board assembly. Instead, it simply slips over CON1 and CON2 and is then slid into the rear slot when the assembly is fitted into the bottom half of the case. Finally, the completed assembly is fastened in place using eight 6mm-long 4-gauge self-tapping screws.

Does it work?

Now for the final checkout, to make sure it's working properly.

First, turn all three front-panel pots fully anticlockwise, then apply power from a suitable 14-18V DC plugpack (or a 12V battery). Check that the green power LED immediately begins glowing.

If it does, check the voltage on REG1's output lead (ie, the righthand lead) with your DMM – it should be very close to +12V with respect to ground. Similarly, the voltage at REG2's (righthand) output pin should measure very close to +6V.

If you now plug an 8Ω speaker into CON3 and then turn up audio gain control VR3, you should hear a small amount of hiss and noise. When you

Table 2: Capacitor Codes

Value	μF Code	EIA Code	IEC Code
470nF	0.47μF	474	470n
100nF	0.1μF	104	100n
47nF	0.047μF	473	47n
22nF	0.022μF	223	22n
10nF	0.01μF	103	10n
4.7nF	0.0047μF	472	4n7
2.2nF	0.0022μF	222	2n2
1nF	0.001μF	102	1n
390pF	–	391	390p
15pF	–	15	15p
10pF	–	10	10p

The receiver is easy to drive, with just four front-panel controls. These are (from left to right): RF Gain, Channel Select, Muting Level and Audio Gain. In addition, there are two holes in the front panel to provide screwdriver access to the 10-turn pots (VR4 & VR5) during alignment.

turn up the RF gain control VR1 as well, this noise should increase a little further but LED1 shouldn't begin glowing except only very faintly when VR1 is turned fully clockwise.

Now turn VR1 fully anticlockwise again and use your DMM to measure the DC voltage at the top of the 390kΩ resistor located just behind transistor Q2 (ie, to the right of 5.1V zener diode ZD1). The voltage across this resistor should be less than 0.30V and preferably about 0.26V. If it's any higher than 0.30V, the IF amplifier in IC1 may be unstable.

Assuming that your receiver has passed all these tests, it should be working correctly and is now ready for alignment.

Receiver alignment

A final "touch up" alignment of the receiver is best done with a satellite signal. However, you need to give it a basic alignment first so that you can at least find the signal from a satellite when it's within range.

For the basic alignment, you'll need access to a frequency counter capable of measuring up to 150MHz and an RF signal generator which can be set to give an output at 137.50MHz and at 137.62MHz. It should be able to provide either unmodulated (CW) output or frequency modulation, with a modulating frequency of 2.4kHz and a deviation of ±25kHz or thereabouts.

If the generator can't be accurately set to the above frequencies, you'll need to use the frequency counter to help set its frequency. You'll also need your DMM during the "tuning-up" process, to monitor received signal level.

The first step is to set the local oscillator frequencies for the two reception channels. This is done by adjusting trimpots VR4 and VR5 respectively, while measuring the oscillator's frequency with the frequency counter. The oscillator signal is coupled to the counter via a "sniffer" coil which is connected to the end of a coaxial cable. The other end of this cable is then connected to the counter's input.

Note that there is no direct physical connection between the oscillator coil and the counter's sniffer coil. Instead, the sniffer coil is placed about 9mm in front of oscillator coil (L3) and roughly on-axis (ie, just in front of the 10pF capacitor).

The sniffer coil can be made by winding four turns of 0.8mm enamelled copper wire on a 5mm drill shank. Its ends can then soldered ends to a BNC socket which is then connected to the end of the counter input cable (see photo). This arrangement picks up enough oscillator energy to give reliable counter readings, without needing to be any closer to L3 (to avoid "pulling" the frequency).

Assuming you want to receive the NOAA satellites, set the oscillator frequency for channel A to 132.0MHz (using VR4), and the frequency for channel B to 132.12MHz (using VR5). These correspond to reception frequencies of 137.5MHz for NOAAs 12 & 15 and 137.62MHz for NOAA 17. If you want to try for other satellites, you'll need

You can make a sniffer coil for your frequency counter by winding four turns of 0.8mm enamelled copper wire on a 5mm drill shank. Its ends can then be soldered to a BNC socket which is then connected to a plug on the end of a coaxial cable. The other end of the cable is then connected to the frequency counter.

to find out their APT frequency and set the oscillator frequency to 5.5MHz below that figure instead.

Peaking the RF stage

Once the oscillator frequencies have been set, the next step is to peak up the RF stage tuned circuits. This is done by setting your RF signal generator to produce an unmodulated (CW) signal at 137.5MHz, initially with a level of about 30μV. That done, connect the generator's output to the antenna input of the receiver, using a series DC blocking capacitor if the generator doesn't have one (so that the generator doesn't short out the +12V phantom power for the masthead amplifier).

Next, connect your DMM (set to the 5V DC range) across the 390kΩ resistor just behind Q2 and make sure switch S1 is set to the channel A position. Now turn up RF gain control VR1 to about midway and use an alignment tool or a very small jeweller's screwdriver to adjust trimcap VC2 until you find a peak in the voltage reading on the DMM. If you can't find a peak, you may have to pull the turns on coil L2 slightly further apart to reduce its inductance.

Once the peak is found, adjust VC2 carefully to maximise the DMM reading (the DMM is reading the RSSI voltage from IC1, so it's essentially showing the received signal strength).

When you're happy that the L2/VC2 circuit is tuned to 137.5MHz, check the actual voltage reading of the DMM. If it's more than 2.5V, reduce the output level from the RF generator until the DMM reading drops to about 2.0V.

You're now ready to peak the receiver's input tuned circuit – ie, L1

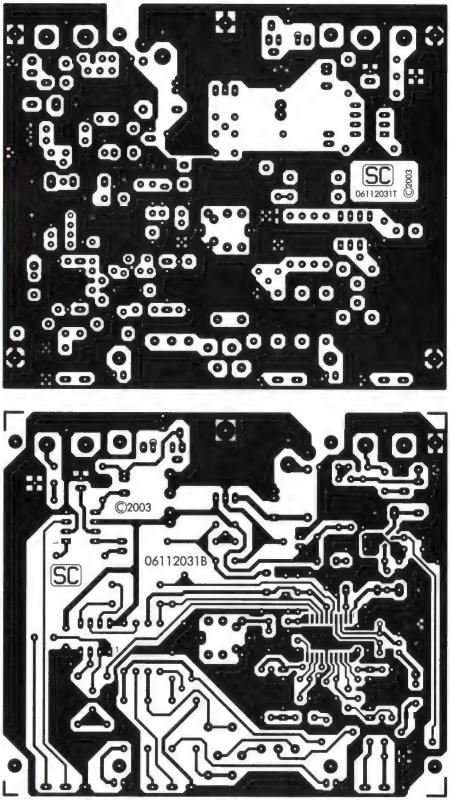


Fig.5: here are the full-size (top and bottom) etching patterns for the PC board.

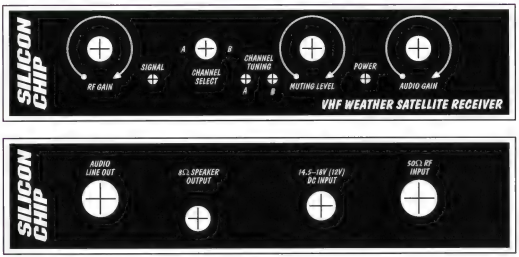


Fig.6: these two full-size artworks can be photocopied and used as drilling templates for the front and rear panels.

and VC1. This is done in exactly the same way as for L2 & VC2. Just adjust VC1 slowly until the DMM indicates a peak and then carefully set VC1 for the maximum peak reading. If you can't find another peak, you may need to pull the turns of L1 slightly further apart as before.

Peaking the quadrature coil

The final alignment step is to set the slug in quadrature detector coil L4 to the correct position for optimum FM demodulation of the 5.5MHz IF signals. This is done by first switching the signal generator so that it's still producing a 137.5MHz signal but this should now be frequency modulated – preferably with a 2.4kHz tone and a deviation of about ±25kHz.

That done, connect an 8Ω speaker to the receiver's speaker socket (CON3) and turn up the audio gain control (VR3) to about the 10-o'clock position. You may not be able to hear the 2.4kHz modulating signal at this stage but in any case, slowly and carefully adjust the slug in L4 using a non-magnetic alignment tool. Sooner or later you'll start to hear the 2.4kHz tone and you should also be able to tune the coil for maximum audio level and minimum distortion and noise.

Once this has been done, the basic alignment of your weather satellite receiver is finished and it's ready for final alignment using the signals from a weather satellite. But before you'll be able to do this, you'll need to build a suitable antenna and mast-head preamp. They'll be described in another article next month. **SC**

This view shows the rear panel layout. There are two RCA sockets (one at each end) for the antenna and audio output signals, a 2.5mm DC power socket and a 3.5mm stereo jack socket for the loudspeaker.

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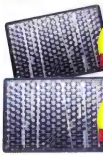

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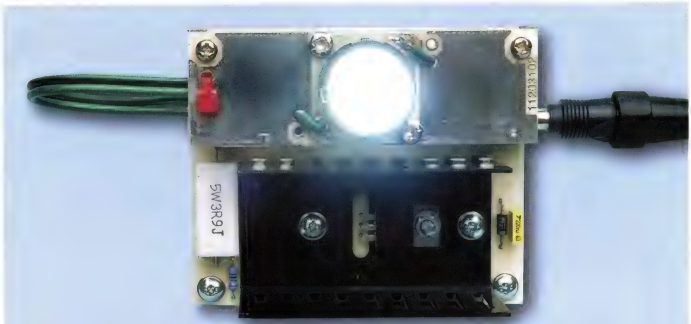


Power the brightest LEDs on Earth with this simple linear supply!

Want to run one or more Luxeon 1W Star white LEDs from a 12V battery or a DC plugpack? This circuit allows you to do it and allows for dimming as well. It uses bog-standard parts, including a 555 timer and two 3-terminal regulators.

By PETER SMITH

Back in the May 2003 edition, we described two of the brightest LEDs available anywhere – Lumileds' 1W and 5W Luxeon Stars. Understandably, the article generated lots of interest, with many readers resolved to wiring up their own Stars and seeing this dazzling new technology first hand.

Unlike the (much) smaller 3mm and 5mm LEDs that we're all familiar with, driving these new devices with just a series current-limiting resistor can be a bit risky. A better way is to power them from a constant current source, to achieve full brightness without exceeding maximum ratings.

This simple circuit will allow you to drive the 1W version (any colour) with the maximum rated current and keep it cool as well. It also gives you control over LED brightness, which can be varied from about 10% to 100% with an on-board potentiometer.

How it works

The circuit diagram for the power supply appears in Fig.1. It consists of two main elements – a current source and a variable duty cycle oscillator. Let's examine the current source first – it uses a LM317 3-terminal regulator (REG1). Commonly, these regulators are programmed with two resistors to provide a particular output voltage, as shown in Fig.2. To maintain the programmed output voltage, the regulator keeps the difference between its 'ADJ' and 'OUT' terminals equal to an internal 1.25V reference.

Fig.3 shows that without the resis-

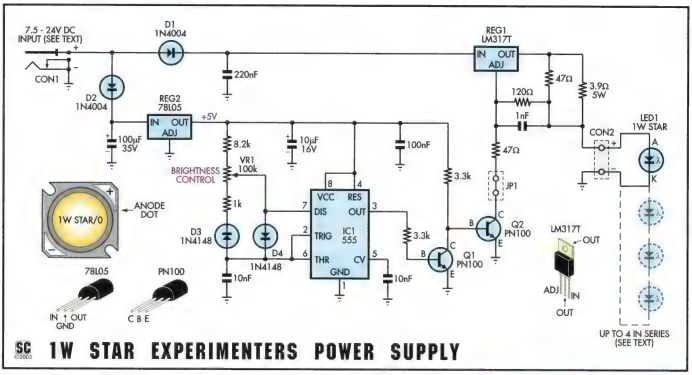


Fig.1: the circuit is based on an LM317 regulator and 555 timer. The regulator is connected as a 350mA constant current source, with its 'on' time varied by the 555 to control LED brightness.

Main Features

- Simple construction
- Variable LED brightness
- Plugpack or battery powered
- Drives 1 to 4 x 1W Luxeon Stars

tor to ground (R2), the regulator still maintains 1.25V across R1. But rather than a regulated voltage, we now have a constant current source proportional to 1.25V/R1.

Calculating R1 for our 350mA Star is easy:

R1 = 1.25V/350mA = 3.57Ω

Referring again to the main circuit (Fig.1), you can see that 'R1' consists of 3.9Ω and 47Ω resistors in parallel, for a total resistance of 3.6Ω. Unlike the simple schematic in Fig.3, the output is connected back to the 'ADJ' pin via a 120Ω resistor. This additional resistor has virtually no effect on the programmed current and its purpose will become clear in a moment.

For our description thus far, we've assumed that JP1 is open circuit. But what happens when it's shorted? Well, when transistor Q2 switches on, the LM317 begins to regulate the output voltage (instead of current), with the 120Ω and 47Ω resistors forming 'R1' & 'R2' as depicted in Fig.2. The output voltage will be:

V_{OUT} = 1.25V(1 + 47Ω/120Ω) = 1.7V

Taking into account Q2's collector to emitter saturation voltage, the output voltage is slightly higher than our calculated value. However, it's still less than the minimum forward voltage of the red/amber and white/blue Stars (about 2.3V and 2.8V respectively), so the LED will be switched off.

Pulse-width modulation

Rather than reducing drive current, Luxeon recommends using pulse width modulation (PWM) switching to reduce the brightness of the Star. This results in a much more colour-uniform light output, right down to minimum brightness. If you just vary the drive voltage in a linear fashion, the Star's light output tends to become yellowish as the drive voltage is reduced.

PWM switching is just a matter of switching the LED on and off at a fixed frequency and varying the duty cycle (on/off time) to vary brightness. With a high enough frequency, the switching effects are invisible. This is due to the long persistence of the phosphors (in white LEDs) and the natural light integration of the human eye.

As you've probably guessed, transistor Q2 in our circuit is responsible for switching the current source (REG1) to give PWM control. Q2 is driven by Q1, which is simply a buffer and inverter stage. The real work is performed by IC1, an old 555 workhorse.

IC1 is configured as a free-running oscillator (or "astable multivibrator") with a nominal frequency of about

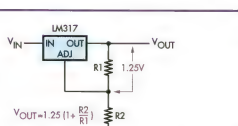


Fig.2: the LM317's output voltage is set with two resistors.

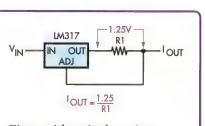


Fig.3: with a single resistor between its 'OUT' and 'ADJ' terminals, the LM317 acts as constant current source.

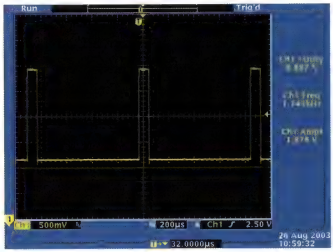


Fig.4: these two waveforms were captured at the output of the supply. With the brightness pot (VR1) set to minimum resistance, only 9% of the power is delivered to the LED.

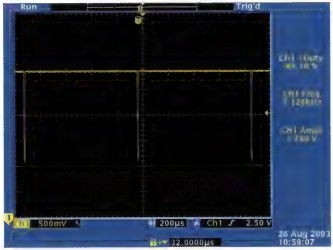


Fig.5: when trimpot VR1 is at the maximum setting, a duty cycle of 99% drives the LED at virtually full brilliance.

1.1kHz. Diodes D3 & D4 provide independent charge and discharge paths for the 10nF capacitor, allowing the duty cycle to be controlled without much variation in the frequency of oscillation.

As a result, trimpot VR1 can vary the duty cycle from 9% to 99% (see Figs.4 & 5), resulting in an average current of between about 30mA and 346mA. Even at minimum brightness, you can still read a book by one of these little marvels!

When driving 3 or 4 LEDs in series, the circuit input voltage can exceed 18V (the 555's max. supply voltage), so we've provided a separate +5V supply for the 555 and associated circuitry. This is generated by REG2, a 78L05 low-power regulator.

Input to REG1 & REG2 is via series diodes D1 & D2, ensuring nothing bad happens if the supply is accidentally reversed.

Input power (single LED)

For a single Star, the input voltage should be between 7.5V and 12.5V. This means that you can drive it from a 7.5V or 9V plugpack (min. 500mA rating), or a 12V SLA battery. 12V plugpacks are generally not suitable, because they put out excessively high voltages when lightly loaded.

The maximum input voltage that can be applied is limited by available power dissipation. When properly mounted to the specified heatsink, the temperature rise of regulator REG1 is about 25°C above ambient with a 12.5V input. This is well within the regulator's rating and the heatsink won't burn your fingers or start a fire!

The minimum input voltage is governed by circuit overhead (about 3.9V) and the LED's forward voltage (about 3.4V for white or blue Stars). So for a single white or blue Star, about 7.3V minimum is required to obtain full brilliance.

Driving multiple Stars

Up to four stars (any colour) can be driven in series. The recommended voltage ranges are shown in Table 3. This should be considered as a rough guide only, as the total voltage across any LED string will vary considerably, according to LED colour and individual device characteristics.

The optimum input voltage can be established using a variable power supply. When the LEDs just reach maximum brilliance, the minimum input voltage has been established. Alternatively, monitor the voltage drop across the 3.9Ω resistor while slowly increasing the input voltage. When it reaches 1.25V, the LM317 is in regulation and therefore sourcing the full 350mA.

Using a lower voltage than recommended will result in less than maximum brightness, whereas higher voltages may (eventually) overheat the assembly.

The LM317 regulator has in-built over-temperature protection and can survive short-term abuse. However, extended high temperatures will eventually destroy it and burn (or delaminate) the PC board.

If the heatsink is too hot to touch, then the input voltage is too high!

Note: do not attempt to drive these LEDs in parallel. Although possible,

Table 2: Capacitor Codes

Value	µF Code	EIA Code	IEC Code
220nF	0.22µF	224	220n
100nF	0.1µF	104	100n
10nF	.01µF	103	10n
1nF	.001µF	102	1n

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	3.3kΩ	orange orange red brown	orange orange black brown brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	1	120Ω	brown red brown brown	brown red black black brown
❑	2	47Ω	yellow violet black brown	yellow violet black gold brown

parallel configurations require voltage-matched devices.

Power supply board assembly

All parts (except for the LED) mount on a single PC board, coded 11112031. Using the overlay diagram in Fig.6 as a guide, begin by installing the two wire links, followed by all of the 0.25W resistors.

Diodes D1-D4 can go in next, making sure that you have the cathode (banded) ends oriented as shown. Follow up with the two transistors (Q1 & Q2), 78L05 regulator (REG2) and trimpot (VR1).

All remaining components, apart from the LM317 (REG1) and its heatsink, can now be installed. Note that the 555 timer (IC1) and electrolytic capacitors (100µF & 10µF) must go in the right way around.

The final step involves mounting the heatsink and installing the regulator. To do this, first secure the heatsink firmly to the PC board with two M3 x 6mm screws, nuts and flat washers. Next, bend the regulator's leads at 90° about 3mm from the body and temporarily slip it into position.

Verify that the hole in the regulator's tab lines up with the hole in the heatsink, which should in turn match the hole in the PC board underneath. If all is well, you can now remove the regulator and apply a thin smear of heatsink compound to both the rear of the metal tab and the mating area on the heatsink surface.

Finally, slip the regulator back into position and fasten it securely to the heatsink & PC board with an M3 x 10mm screw, nut and washer. Solder and trim the leads to complete the job.

Note: the metal tab of the regulator is internally connected to the 'OUT' terminal, so the heatsink will be live. The LED (and any other uninsulated wiring) must not be allowed to make contact with the heatsink! If you don't like this idea, then you can mount the regulator to the heatsink using an insulating pad and washer. The down-side to this arrangement is higher regulator temperature.

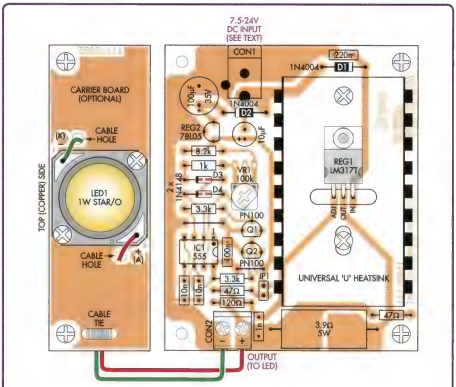
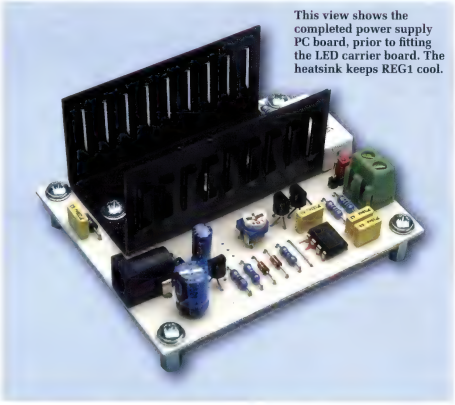


Fig.6: follow this diagram closely when assembling your boards. To make the job easier, leave the heatsink and regulator (REG1) until last.



This view shows the completed power supply PC board, prior to fitting the LED carrier board. The heatsink keeps REG1 cool.

LED mounting

The Star's emitter and collimating optics are mounted directly onto an aluminium-cored PC board. In most cases, no additional heatsinking is required. However, a small heatsink reduces junction temperature significantly and ensures maximum LED life.

Just about any small aluminium heatsink with a flat area large enough to accommodate the Star's 25mm footprint can be pressed into service. For example, an old 486 PC processor

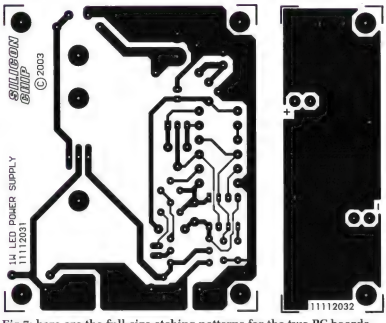


Fig.7: here are the full-size etching patterns for the two PC boards. Check your etched boards carefully before installing the parts.

heatsink would probably be ideal!

For experimentation purposes, an area of PC board copper also does the job nicely. This is the purpose of our simple "carrier" board, which also provides a convenient mounting and terminating method for the LED module.

LED carrier board assembly

Before mounting the LED module, make sure that the mating surface is completely smooth. If there are any "lumps" of solder, then they must be removed using desoldering braid.

Apply a thin smear of heatsink compound to the rear of the LED module as well as to the mating surface (copper side) of the PC board. The module can then be attached to the PC board using two M3 x 6mm screws, nuts & washers.

With opposing corner holes, the module could be mounted one of two ways. To determine the correct orientation, look for a tiny copper "dot" next to one of the corner solder pads. This indicates positive (+) and should be aligned as shown on the overlay diagram (Fig.6).

Once mounted, all that remains is to wire up the LED anode (+) and cathode (-) terminals, provided in the form of two solder pads on opposite corners of the module's PC board.

Solder a short length (about 15cm) of wire to one of the pads and pass it through the neighbouring hole in the carrier board. Repeat for the opposite pad and then twist the two wires together under the board. Secure at the end of the carrier board with a small cable tie to ensure that no tension can be applied to the solder joints.

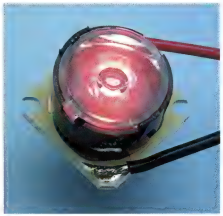
Before connecting your LED to the power supply output terminals, it's important to verify that the supply is working properly. A faulty supply could destroy your $30+ investment in a blinding flash!

Testing

Connect a 10Ω 5W resistor directly across the power supply output terminals. Position the body of the resistor so that it is clear of your workbench (and your pinkies!), as it could get extremely hot. If you fitted a jumper shunt on JP1 earlier, remove it for now.

Table 3: A Rough Guide To Input Voltage Ranges

No. of Stars	Min. Voltage	Max. Voltage
1	7.3V	12.5V
2	10.7V	15.9V
3	14.1V	19.3V
4	17.5V	22.7V



The 1W Star LED is available in seven colours: white, green, cyan, blue, royal blue, red and amber. They can all be driven by this power supply.

Plug in your chosen DC power source and hit the "go" switch. Assuming there are no ominous bangs or puffs of smoke, use your multimeter to measure the voltage drop across the 10Ω resistor. If the supply is sourcing the expected 350mA (nominal) of current, your measurement should fall within the 3.2V - 3.8V range.

Power off, disconnect the resistor and then re-apply power. Measure the voltage between pins 1 & 8 of the 555 (IC1). These are the power supply pins, so your meter should read 5.0V or thereabouts.

All done! Assuming your board passed the tests, hook up the LED leads to the output terminals. Be particularly careful that the anode (+) terminal of the LED connects to the positive (+) output, as the LED module will be destroyed if reverse voltage is applied.

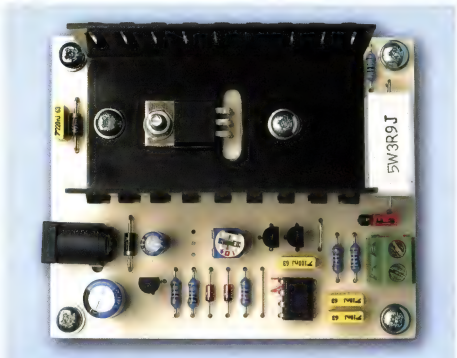
Hold your breath and power up. Don't stare directly into the LED beam at close range, as it is (according to Luxeon) bright enough to damage your eyesight!

Brightness control

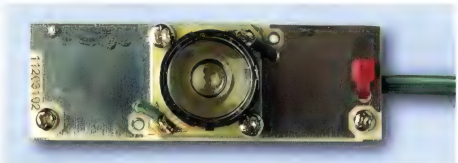
To enable brightness control, install a jumper shunt on JP1. Now by rotating VR1, you should be able to vary LED intensity from dim to almost full brightness.

LED carrier board mounting

To make a neat "one-piece" module, the LED carrier board can be mounted



Take care to ensure that all polarised parts are correctly oriented when building the power supply PC board. Note that this prototype PC board differs slightly from the final version shown in Fig.6.



The completed LED carrier board provides a convenient method for mounting the 1W Star LED module and also provides heatsinking.

piggyback style on the power supply board.

To do this, insert an M3 x 25mm screw in one corner hole and slide on a 15mm spacer from the bottom. Wind up an M3 nut to hold the spacer in place, then repeat for the other corner. The completed assembly can now be slipped into place in the two corner holes of the power supply board, replacing the existing M3 x 6mm screws (see photos).

With the carrier board installed, you'll note that the brightness trimpot (VR1) is no longer easily accessible. If you need to continually vary the brightness with the board in-situ, then you can either reposition the trimpot to the opposite (copper) side of the board or install an external potentiometer.

When installing an external pot, keep the wire length as short as possible (say, no more than about 50mm) and twist the three connecting wires tightly together.

Where to get the Stars

The 1W Luxeon Star LEDs are currently available from the Alternative Technology Association at **www.ata.org.au**. You can check out their on-line shop at **shops.bizarsoftware.com.au/ATAShop**.

Lumileds also manufacture higher output (5W) white and blue Stars. Naturally, these devices are considerably more expensive that the 1W versions and require more elaborate heatsinking. Their higher current requirements (up to 700mA) make them unsuitable for use with this supply.

Detailed technical information on Luxeon Star LEDs can be obtained from the Lumileds web site at **www.lumileds.com**. SC

Parts List

1 PC board, code 11112031, 80mm x 66mm
1 2.5mm PC-mount DC socket
1 2-way 2.54mm terminal block
1 2-way 2.54mm SIL header
1 jumper shunt
1 Universal 'U' heatsink
4 M3 x 10mm tapped spacers
1 M3 x 10mm pan head screw
6 M3 x 6mm pan head screws
6 M3 flat washers
3 M3 nuts
Red & black light-duty hook-up wire
Heatsink compound
1 9V DC 500mA (min.) plugpack (see text)
1 100kΩ miniature horizontal trimpot

Semiconductors
1 LM317T adjustable voltage regulator (REG1)
1 78L05 +5V regulator (REG2)
1 555 timer (IC1)
2 PN100 transistors (Q1, Q2)
2 1N4004 diodes (D1, D2)
2 1N4148 diodes (D3, D4)
1 1W Luxeon Star LED w/optics (see text)

Capacitors
1 100µF 35V PC electrolytic
1 10µF 16V PC electrolytic
1 220nF 63V MKT polyester
1 100nF 63V MKT polyester
2 10nF 63V MKT polyester
1 1nF 63V MKT polyester

Resistors (0.25W, 1%)
2 3.3kΩ 1 120Ω
2 1kΩ 2 47Ω
1 10Ω 5W 5% (for testing)
1 3.9Ω 5W 5%

Parts for optional LED carrier

1 PC board, code 11112032, 80mm x 26mm
2 M3 x 15mm untapped brass or nylon spacers
2 M3 x 25mm pan head screws
4 M3 x 6mm pan head screws
6 M3 nuts
4 M3 flat washers
1 small cable tie

SERVICEMAN'S LOG

Turn it upside down to fix it!

I've seen customers do some strange things over the years but here's one that you won't believe. He actually tried to fix an intermittent fault in his TV set by operating it upside down! Had he been successful, I presume he would have then watched TV standing on his head!

I recently received a call from our local RetraVision store, asking me if I would have a word with one of their customers who had a faulty TV. Naturally, I said yes (I need the money) and after recording her details, I asked what sort of set she had. She wasn't really sure but thought it was a 2½-year old Sony!

After that response, there was no point in asking what the model number was, so I asked what the problem was.

According to the customer, the set's picture would "intermittently go white" and then the set would switch to standby. I asked her to explain what she meant by "intermittently" and was told that sometimes the fault would appear after about one hour while on other occasions the set would last for most of the day.

Unfortunately, this type of intermittent fault cannot readily be fixed in the home. That's because the fault might not show when I called and even if it did, I couldn't possibly guarantee that the problem had been fixed without prolonged soak testing. So in a nutshell, it had to go to the workshop to be repaired.

The customer accepted this and so we arranged that I would call and pick the set up the next afternoon. And because it was an 80cm set, I asked if there was anyone there who could help me load it into my station wagon or would I have to bring someone with me. To my surprise, she said that she would help me with the set and wasn't even the slightest bit fazed even when I told her that it could weigh up to 80kg!

As far as she was concerned, it wasn't a problem. She worked as a nurse and was able to lift patients, so she could easily manage this!

A unique cure

The next afternoon, I dutifully arrived and reversed up her steep drive and opened the tailgate of the wagon in anticipation – mentally noting the number of steps up to the verandah. However, when I knocked on her door, she said "you are going to be disappointed – my husband has decided to try fixing it himself first. If it's still giving problems after two weeks, then you can pick it up".

Naturally, I was rather peeved by this. At the very least, she could have rung and told me this before I drove out to pick the set up – service calls are expensive.

Anyway, I was intrigued as to how her husband intended to fix the set and she showed me into her living room to see what they were doing. The set was a fully imported model they had bought with them from Czechoslovakia and it was a Sony KV-29X5K – a model I had never seen before (possibly a BE3D chassis?)

Items Covered This Month

- Sony KV-29X5K TV set (FE-1 chassis).
- Philips 32PW9631/05 Widescreen TV (GFL2.3E chassis).

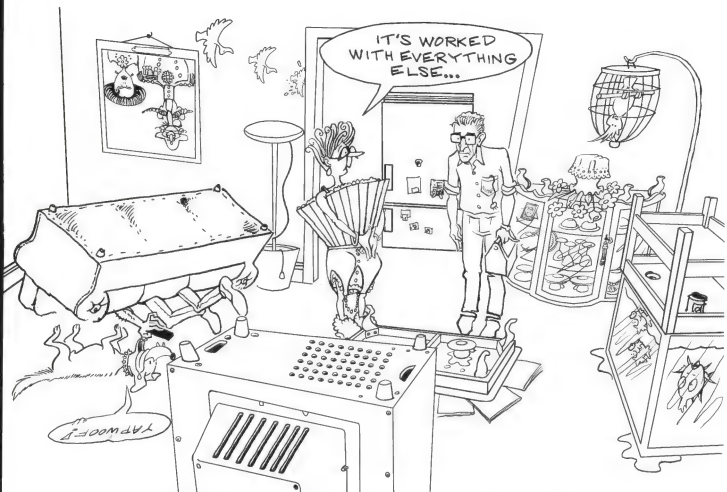
Anyway, their approach to solving this fault was to operate the TV completely upside down on their lounge room floor! I wished them good luck and left, grateful in the end that I had got out of the job.

Later, I speculated on just what they were trying to achieve by turning the set upside down. In the end, I could only surmise that because the set was originally from the Northern Hemisphere, they thought that rotating it in the Earth's magnetic field might fix the problem. However, this is for a colour purity problem and would not affect this particular fault. And in any case, a 2½-year set would probably have a "Terrestrial Magnetism Correction System" (TMCS) fitted (available since February 1998) to compensate for any geomagnetic effects on the tube's shadow mask.

In greater detail, TMCS is a relatively new technology that was developed to overcome the effects of regional (horizontal) magnetic field variations on the picture tube. In Europe and the USA, for example, the average field strength is about 35mT (milli-Teslas) compared to 30mT in Japan and 40mT in Malaysia, Singapore and Hong Kong. However, large regional variations can exist (eg, due to geological factors) and even the presence of a lot of steel in a building can have a localised effect.

In fact, if the set is located in an area with a strong local magnetic field, you can see the effect change the on-screen colours as you move or rotate the set around. Because of this, all TV sets are fitted with an automatic degaussing circuit to demagnetise the shadow mask in the picture tube every time it is switched on from cold (it takes about 20 minutes for the dual posistor to cool down again).

The TMCS system takes this a step



~THEIR APPROACH TO SOLVING THIS FAULT WAS TO OPERATE THE TV COMPLETELY UPSIDE DOWN...

further. It relies on a geomagnetic sensor (MIU-102-N) which detects the horizontal magnetic field and varies the DC current through a beam-loading correction coil (LCC). This coil is placed near the tube and corrects the purity using Fleming's lefthand rule. In addition, a separate "Rotation Coil" is fitted and this corrects image rotation and horizontal trapezoidal distortion.

The TMCS in some models is automatic but in others you can adjust it with an on-screen menu until the colour purity is correct.

Anyway, predictably, the Sony TV didn't respond to the upside down treatment and eventually arrived at my workshop. This time, there was an additional rider on the fault symptoms. Previously, it would go white then fold to a horizontal line before cutting off. However, it was going to a vertical line before cutting off inside one hour of being turned on (these being the symptoms for vertical and horizontal timebase failure respectively).

The first problem I had was to try and get some service information on this set, so I surfed the net for answers. Eventually I found out that SCC-QO3A-A translates into a 1998 68cm FE-1 chassis made in Spain.

Service mode

Next, I discovered how to get into the "Service Mode" – ie, go to the Standby Mode and press the i+, 5, vol+ and TV buttons on the RM-883 remote control. This is slightly different from most Sonys, which substitute the "TV" button in this sequence for the "Power" button. You would have thought the set would switch on as soon as you pressed "5" but it doesn't in this sequence.

From the on-screen data menu, I discovered the software to be v5.54-00, the factory data FFh6Ch, the destination K and the text language as EAST (TV Status), as well as Status Reg 1 = 11001101 and Status Reg 2 = 10000001 (Technical).

The instructions said that there is a Test Mode 2, which is available by pressing "TEST" button 13 twice on the remote to produce "TT On Screen Display". The only problem is that there isn't a "TEST" button, nor "13". I tried 1 and 3 together and in sequence but it made no difference.

When you enter the Service Mode, the following OSD message appears:

1-AY-C-TT- -
- - - - - - - - -K E

and if you key in any two numbers, they will appear after the TT accompanied by a change in the picture (eg, 13 makes the picture darker). "MENU" enables a Test menu and to get into the diagnostic mode, you press i+, 5, vol– and TV. This produces a table of errors and their frequency, plus the set's on-time duration.

In this case, I had 69 x error 2

(protection circuit trip), 24 x error 5 (AKB), 1 x error 8 (jungle controller, no I^2C acknowledge at Power On), 3 x error 9 (Tuner, no acknowledge at Power On), 3 x error 10 (sound processor, no acknowledge at Power On). The set had been running for 008905h 49m since 1998.

I cleared the error buffer with 80 and then switched the set on and waited for results. Naturally, I wasn't able to sit there for an hour, waiting for the fault to appear, so I left it in a prominent place in the hope that I would observe something when it did happen. Of course, I was somewhere else when the fault finally did occur. I returned to find that the set was dead, with the front-panel LED flashing twice every second.

I turned it off and on again and it switched straight back onto a perfect sound and picture, the Service Mode now showing an "Error 2".

Next, I removed the chassis and examined it carefully for anything obvious before thoroughly resoldering it from "stem to stern". That done, the set was reassembled and placed on a prolonged soak test.

The set then worked perfectly for a whole week. But then just as I had quoted for the repair and made an appointment to return the set, the fault (error 2) reoccurred. This fault then reoccurred three more times, each over four hours apart.

My next line of attack was to monitor the +135V rail with a digital multimeter that has peak-hold to see if it increased over the next few hours. However, this didn't reveal anything as the meter kept timing off but I was fairly happy that this wasn't the problem area.

In the meantime, the client, on my suggestion, came up with an unofficial modification they had got from somewhere in the old country. It involved cutting the ground track to one of the filaments of the CRT, both on the CRT board C and the deflection board (A) around the flyback transformer, thus completely isolating the picture tube heaters and apparently "discarding its overcurrent protection" – though I don't quite see why in this case.

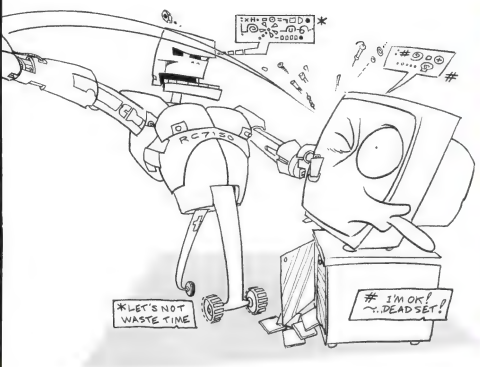
The LED flashing twice indicates a fault in the secondary excess-current protection in the line output stage. If the current increases across R572, the extra voltage (1.2V) switches on Q571 and Q574. The resulting signal is then applied to pin 18 of the jungle chip (IC301) and pin 52 of microprocessor IC001, which switches the set off.

Apparently, if there is a flashover or irregular short inside the CRT (eg, a heater to cathode short), the voltage across the filaments increases with respect to ground. This causes excess current to flow through the flyback transformer and switches the set off as described above.

Anyway, I did the modification while not expecting too much but was pleasantly surprised when it was still operating over 72 hours (continuously) later. The set was then returned to its owner with the rider that the picture tube could be on the way out.

Subsequently, I have found similar modifications in some Sony TVs to desensitise the current protection circuit by changing the 1Ω feed resistor (R572) to the line output stage to 0.56Ω.

I think it would be a great help if



THIS IS A VERY SPECIAL REMOTE CONTROL THAT CAN INTERROGATE & DIAGNOSE DEAD SETS

I could just get a copy of this circuit from Sony.

Wide-screen Philips TV

A large wide-screen Philips TV greeted me one Monday morning, as I stared at my once vacant bench sipping my coffee. How it got there over the weekend I don't know but I suspect Mrs-she-who-has-to-be-obeyed had a hand in it.

Anyway, this beautiful state-of-the-art (1995) 76cm Philips 32PW-9631/05, fully imported from Belgium and expensive, was dead. Could I do a Lazarus on her?

I removed the large back to be confronted with a pile of electronic circuitry that was being eaten alive by that dreadful cancer called salt corrosion. Still, on the bright side, it wasn't completely dead – the front stand-by LED was flickering.

The chassis number printed on the back said S5GFL2.30E which I translated to be GFL2.30E.

My next step was to try to determine how far the power was getting into the set but the chassis was unfamiliar and the access wasn't the best. I ordered a service manual but unfortunately it arrived with two pages missing which, as it turned out, contained critical information.

After I had discovered the concealed screws and clips (and breaking only a few), I managed to lower the large turret on the right (Audio Amplifier A Board, lO Dolby U Board, AFU Z Board, and ECO Low Power Standby AU Board). I also discovered how to lower the Service Selection Board I.

That done, I tackled the "Large Signal Panel" where I discovered that the +141V was cut off from the line output transistor via the line switch FET (7480). This, in turn, is controlled by the "Slow-down" and "Fast-down" protection circuits, the former coming from the "Small Signal Panel" (SSP) via plug S/L11 (pin 21). However, all was revealed when I examined the small signal panel. This board is double-sided with very fine tracks and it was very corroded. Similarly, the Teletext board (AQ) and the Source Selector (I) were also corroded.

I removed the SSP and saw that it was probably beyond economic repair. I then tried to obtain a new or exchange board from Philips but it is no longer available. And so, after a "heart-to-heart" with the customer, and a lot of crying on their part over the expense, they agreed that they would pay me to repair this panel.

First, I removed it and washed it in hot water to remove the salt. I then

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use Nifti to remove the dirt and grease before thoroughly drying it. That done, I washed it in "metho", after which the board was thoroughly cleaned using a professional PC-board cleaner solvent. Finally, I left a very fine spray of CRC 2-26 all over the board surfaces which I then blew off with an air-compressor.

Next, I got out my continuity tester and checked what felt like thousands of interconnections across and through this double-sided board, fitting links where necessary. The two worst were the corroded connections from S31 pin 1 (+5V standby) to the I/O board and the Power-On Reset line between Q7214 and R3205. Once I had repaired these two, I was able to power up the set and get a picture!

However, the picture was very poor with no sound. There was east-west distortion and the picture-in-picture (PIP) was barely working.

To diagnose this problem, I first connected service pins 2 and 1 on socket S98 on the SSP to get into the "Service Alignment Mode". This gave all sorts of information, including the Operating Hours, ID, Option Codes and Error Codes, plus alignment details. It also reported Error 013, IC7814 TMP47P443VN, which is on the I/O module (I).

Unfortunately, this was the start of a huge amount of time wasting from misinterpreted data. I followed up each of the remaining four faults, looking for possible shared causes like missing power rails and corroded tracks, etc but got nowhere.

Sound problem

The "no-sound" problem should have been the easiest fault to locate. Indeed, it started well when I traced the sound from the tuner (F) to the stereo decoder and from there to the sound processing circuitry. I was then able to trace the sound via the source selection switching and all the way to the AFU module (Z).

Personally, I thought I was particularly brilliant to do this, considering very few of the circuits in the service manual I had exactly corresponded to the circuits in the set. But now I was really stumped because I had nothing on the AFU (Audio Feature Unit) at all, as the pages were missing. That really made things difficult, as this is a large module containing eight ICs for Dolby Surround Sound before continuing onto the "Dynamic Enhancement" circuitry and audio amplifiers (plus headphone amplifiers).

As for the other problems, the east-west circuitry was only just working and the digital software controls had little effect. And the picture-in-picture was not centred and only half there.

I was about to give up in disgust after all the effort I had put into this repair when I had a bit of luck. Stuck on the picture tube are the option codes for each variation of this set and I noticed that the numbers didn't correlate with the model I had on the bench. Initially, I didn't think that this meant much but, lacking any other ideas, I wrote down the ones programmed into my set and then programmed the numbers from the label into the set.

And would you believe it? – after storing them and restarting the set, all these faults were fixed simultaneously, apart from a little fine tuning. Perhaps this set is just a little too smart for its own good!

Dealer service tool

Finally, the service manual makes frequent references to a "Dealer Service Tool". This is a very special 2-way remote control (RC7150) that can interrogate and diagnose dead sets! And it can automatically program them as well! However, this tool is just too expensive for me and is not readily available. **SC**

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Seasons Greetings

December 03 ISSUE

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Faraday Hand Powered LED Induction Torch

No batteries required! To use this torch you simply shake it up and down, and the internal mechanism charges a small rechargeable cell to run the LED. When the torch starts to dim, simply shake it again to restore full brightness. It is waterproof, made from strong ABS plastic, and even floats in water. Never get caught with a powerless torch again!

NEW

- Measures 165(L) x 37(dia)mm.

Cat. ST-3340 $14.95

128MB USB Flash Disk with MP3 Player

A USB flash memory disk, and MP3 player in one! It stores up to 2hrs of MP3 music, and requires no software (drivers included for Win98/SE). Includes lanyard and earphones.

- Uses 1 x AAA battery (inc).
- Measures 76 x 37 x 16mm.

Cat. QE-4000 $199

Binoculars with a Mini Digital Camera

NEW

This great unit combines a 300k pixel digital camera, with 8x zoom binoculars! That means that you can capture clear, crisp images from a distance. As well as taking great photo's, it can also store up to 100 seconds of video. Supplied with a handy belt pouch for protection.

- Max resolution 300k (640 x 480) pixel.
- Uses 2 x AAA batteries, included.
- Measures 110 x 90 x 46mm.

Cat. QC-3198 $129.95

Power Dive Radio Controlled Submarine

The ultimate toy for the bathtub, pool, or fish tank. It has full manoeuvrability with forward, back, left & right. It also has a power dive function to quickly get to the bottom. Fitted with an LED headlight, it can even see in the dark! Requires 3 x AAA batteries.

Cat. GT-3045 $29.95

Valve Audio Pre-Amp Kit

NEW KIT

Ref: Silicon Chip Nov 2003.
AT LAST! A valve based preamp kit! It uses a 12AX7 valve, and offers excellent performance. Kit supplied with PCBs, case, valve, ferrite cores, bobbin and clips, and all electronic components. Requires 12VDC @ 250mA.

Cat. KC-5370 $89.95

Valve Preamp Add-On Kit

NEW KIT

Ref: Silicon Chip November 2003. Add to KC-5370 for a stereo valve preamp. Powered from KC-5370, so no extra power is required. Kit supplied with PCB, valve, and all electronic components.

Cat. KC-5371 $59.95

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Cat. XC-1005 $29.95

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Cat. GT-3058 $49.95

Santa's Outhouse with Sounds

NEW

Santa's outhouse shakes, and lets out ghastly sounds. It features 10 different sounds, so you are sure to keep things interesting with this great Christmas novelty. Requires 3 x AA batteries.

Cat. GT-3056 $24.95

Magic Christmas Tree

A fascinating Christmas novelty that will delight young and old alike. Simply follow the instructions, and a dazzling Christmas tree will sprout from the bare tree trunk. It grows in just 12 hours, and will last for days. The kit includes the bare trunk and stand, magic water and crystals, decorations, and a star for the final touch.

Cat. GT-3070 $9.95

Christmas Tree Animated Musical Snow Dome

NEW

The Christmas tree features LED lighting, and as the wind up mechanism is unwinding, the snow whirls, so there is no need to shake it!

Cat. GH-1214 $39.95

Reindeer Animated Musical Snow Dome

NEW

This fascinating dome features a wind up mechanism, which plays a familiar Christmas tune. The snow automatically whirls, so there is no need to shake it!

Cat. GH-1216 $29.95

Santa Animated Musical Snow Dome

NEW

A great addition to the mantle piece. It features a wind up mechanism, which plays a familiar Christmas tune. The snow automatically whirls, so there is no need to shake it!

Cat. GH-1218 $29.95

Farting Salt and Pepper Shakers

Keep the humour alive this Christmas. These shakers make a farting sound when they are tipped upside down.

Cat. GH-1080 $19.95

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A powerful but gentle rechargeable electric corkscrew. Supplied with mains charger.

Cat. YS-5525 $84.95

Mini Waterproof Table Lantern

Bring some light to the festivities. It features a bright Krypton globe. Great for outdoor entertaining this summer. Requires 4 x AA batteries.

Cat. ST-3033 $12.95

3 in 1 Indoor Games Set

NEW

The stylish glass chess board features chamfered edges and acid etched markings and will last a lifetime. It includes chess pieces which are actually shot glasses, and can be used empty, or filled with some form of liquid refreshment. The set also includes two decks of cards and a set of checkers pieces.

- Board size approx. 345 x 345mm

Cat. GT-3005 $29.95

Cocktail Mixer and Accessories

NEW

Making the perfect cocktail is a snap with this unique, clear acrylic cocktail shaker. It has a handy scale for easy mixing, with six popular mixes detailed including Dry Martini, Manhattan, Red Lion and Vodka Dry.

- Supplied with accessories for six people including straws, swizzle sticks, mini umbrellas, ice blocks and coasters.
- Size: 245(h) x 100(dia.)mm

Cat. GH-1152 $14.95

Shot Glass with Red LED

NEW

Just the thing to alert the bartender to fill it up again! Slam it down and the red light will flash for 15 seconds.

- Recommended to hand-wash only.

Cat. GH-1150 $3.95

KEEP EVERYONE ENTERTAINED THIS CHRISTMAS

Electronic Dartboard

This is a great electronic dartboard with sound effects and digital speech, informing you of scores, whose turn it is etc. It features 13 games to choose from, with variations, and handicapping. Great fun for the whole family.

- No metalic tips on darts
- Safe for kids

Cat. GH-1030 $99.95

Magnetic Dartboards

A safe and fun way to play the traditional game of darts. The surface of the board is metallic, and the special darts have flat magnetic tips. There are no sharp tips, so they are very safe for children 8+. Two models available:

Tabletop Version

Fitted with feet to mount on top of a table, and fold away for convenient storage. Supplied with board, 6 darts (3 red, 3 black), and instructions. 270mm diameter.

NEW Cat. GH-1034 $14.95

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Mounts easily on the wall in a games, or family room. Supplied with board, 6 darts (3 red, 3 black), and instructions. 430mm diameter.

NEW Cat. GH-1036 $24.95

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Cat. YS-5545 **$9.95**

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Cat. YS-5542 **$79.00**

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A safe, effective way of relocating creepy crawlies, and insects found in the common household. It has a strong motor, which creates a vacuum effect, sucking them into the tube. You can then release the insects in a more appropriate environment.

Was $29.95
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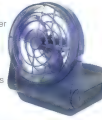
Cat. YY-2850 **$19.95**

Personal Desktop Fan

This great unit features a large 100mm diameter fan, two operating speeds, and adjustable tilt angle. Measures 310 x 160 x 75mm when folded. Requires 2 x D batteries.



Cat. GH-1074 **$12.95** NEW

Personal Fan with Storage Compartment

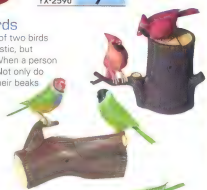
By the pool, in the car, or relaxing under a tree, you can use this handy little fan to keep cool. It has soft blades for safety, and a storage compartment for valuables.

Cat. YX-2590 **$9.95**

Animated Singing Birds

These delightful products consist of two birds (about finch size) perched on a plastic, but realistic looking piece of branch. When a person walks past, they burst into song. Not only do they twitter away to each other, their beaks move, as well as their tails. Require batteries.

Red/Orange Birds Cat. LA-5014
Green/Yellow Birds Cat. LA-5013



BOTH TYPES EA **$14.95**

Animated Singing Birds Alarm Clock

The digital clock can be set to sound on the hour, every hour, or simply when someone walks past. The birds do more than just chirp, they move, with animated beak and tail.

Cat. XC-0245 **$19.95**

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It holds 24 6" x 4" photos, and allows you to record up to 10 seconds of audio onto each page. The perfect gift!

Cat. XC-0288 **$59.95**

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These tiny radio controlled cars are great. 5 different models are available, modelled on the Nissan Skyline, Toyota Supra, Mazda RX-7, Mitsubishi EVO-7, and Mitsubishi Eclipse. All models are available with either racing effects, or a turbo feature, and the cars are just 65mm long.

Nissan Skyline with Turbo Feature Cat. GT-3030
Nissan Skyline with Sound Effects Cat. GT-3035
Toyota Supra with Turbo Feature Cat. GT-3031
Toyota Supra with Sound Effects Cat. GT-3036
Mitsubishi EVO-7 with Turbo Feature Cat. GT-3032
Mitsubishi EVO-7 with Sound Effects Cat. GT-3037
Mazda RX-7 with Turbo Feature Cat. GT-3033
Mazda RX-7 with Sound Effects Cat. GT-3038
Mitsubishi Eclipse with Turbo Feature Cat. GT-3034
Mitsubishi Eclipse with Sound Effects Cat. GT-3039

5 different models each available in 2 styles

Price per Car **$29.95**

Miniature Radio Controlled Battle Tanks

Engage your opponent in a one-on-one tank battle with these fantastic miniature radio controlled tanks. Featuring a rotating turret with an infrared 'cannon' that can fire on an opposing tank. Once a tank is 'shot', it will remain disabled for a few seconds until it is back in action.

Two tanks are required for battle games.

40Mhz Tank Cat. GT-3042
27Mhz Tank Cat. GT-3040

Price per Tank **$44.95**

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KEEP THE CHRISTMAS CALORIES UNDER CONTROL THIS SUMMER

Digital Pedometer with FM Radio

Not only will this little wonder tell you how many steps you have taken, it will also tell you how far you have walked, and how many calories consumed. It also has an integrated FM radio and belt clip.

Cat. XC-0264 **$29.95**

Multi Function Pedometer

Keep track of the amount of walking, running, or jogging you are doing. It is small, and clips onto your belt, making it great for everyday use.

Cat. XC-0262 **$19.95**

Bathroom Scales with Body Fat Analysis

These great scales calculate the amount of body fat you are carrying. It uses 'bio impedance analysis' technology, and can be calibrated for use by up to 8 people.

Cat. QM-7249 **$129.95**

Digital Watch with Pulse and Temp

In addition to standard digital watch functions, it also measures you pulse, and takes body temperature readings through its base.

Cat. XC-0260 **$19.95**

Digital Watch with Pulse and Calorie Counter

Keep track of your pulse rate and energy consumption with this easy to use digital watch. Features also include an alarm, and stopwatch with split time function.

Cat. XC-0266 **$39.95**

Hand Held Body Fat Analyser

Simply enter you weight, hight, age, and sex, then place your thumbs and index fingers on the touch pad. The measurement is displayed on the LCD as a percentage.

Cat. QM-7252 **$29.95**

Sports Stopwatch

A useful addition to any sports bag. Not only does it measure the elapsed time for up to 24hrs, it also has a split time, alarm, and calendar function. Includes a 600mm lanyard.

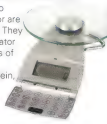
Cat. XC-0270 **$9.95**

Hygienic Electronic Whistle

With personal hygiene and safety and issue concerning us all, our electronic whistle takes care of health concerns, and all the huff and puff. It emits an extremely loud 120dB screech, rivalling a conventional whistle.

Cat. YS-2812 **$19.95**

3Kg Digital Nutrition Scales



Ideal for those who need to monitor their food intake, or are just watching their weight. They double as a nutrition calculator for over 470 different types of food. Measure calories, kilojoules, cholesterol, protein, fat, carbohydrates, and glycaemic index.

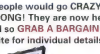
Cat. QM-7240 **$79.95**

WHAT WENT WRONG???

Talking Fridge Magnets

We thought people would go CRAZY over these great fridge magnets, but WE WERE WRONG! They are now heavily reduced, but quantities are strictly limited so GRAB A BARGAIN BEFORE THEY'RE GONE!!! See our website for individual details.

Briefcase
LM-1700


Fax Machine
LM-1712

Filing Cabinet
LM-1714

Public Phone
LM-1726

Fridge Message Clip
LM-1716

Touch Tone Phone
LM-1728

Beer Bottle
LM-1706

Notebook Computer
LM-1718

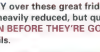


Photo Copier
LM-1708

Lagerbrau (Beer Bottle)
LM-1720

Toilet
LM-1732

Diet Scale
LM-1710

Office Phone
LM-1722

Truck
LM-1734

Were $14.95

ALL TYPES **$4.95ea**

Save $10

Galileo Thermometers

Invented by Galileo hundreds of years ago, these thermometers are as beautiful to look at, as they are functional. The glass spheres rise and fall in the liquid column to indicate current room temperature. Three sizes available:

28cm
Cat. GG-2100 **$29.95**

38cm
Cat. GG-2102 **$49.95**

53cm
Cat. GG-2104 **$79.95**

Soccer Alarm Clock

This is one alarm that you won't be able to sleep through. If the sound of a roaring crowd and flashing lights can't wake you, we don't know what will. See website for details.

NEW

Cat. XC-0246 **$24.95**

Ultrasonic Cleaner

This great unit produces millions of microscopic bubbles. It reaches deep into the cracks and crevices, to remove dirt and grime. It is ideal for jewellery, razors, PCBs etc.

- 80-watt power setting for large objects.
- 35-watt setting for delicate objects such as jewellery.
- 99-second built-in timer.
- LED Digital display.
- Transparent Spill-proof cover.

NEW

Cat. YH-5402 **$99.00**

Flashing Memo Pin

Now you will never forget your reminders. This pin has an adhesive pad for sticking to a monitor, fridge etc., and has a Red LED which flashes when a note is held in place.

NEW

Cat. GG-2200 **$6.95**

OVER 5,500 PRODUCTS IN STORE

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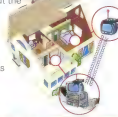
2.4 GHz Wireless AV Sender

Share your Audio/Video signals all over the house without the hassle of running cables, and degrading signal quality. Additional receivers are available separately to allow multiple viewing locations from the one source.



Cat. AR-1832 **$99**

2.4 GHz Wireless AV Sender with IR Remote Control Extender

Similar in design to the AR-1832 (left), with the addition of an Infrared remote control extender. This allows you to control the DVD, Cable TV, or VCR from the remote viewing location.

Cat. AR-1830 **$139**

Extra Receiver with IR Extender

Cat. AR-1831 **$89**

Too Hot To Print

Our Memory Card prices are too hot to put on paper. Drop into any store or see our website for the latest prices.

Dual SIM Card Adaptors for Mobile Phones

If you have multiple SIM cards with different carrier networks, then you need one of these. They allow you to hold two SIM cards in your phone, and switch between them, taking the strain out of changing SIM cards. The electronic 'switch' is simply operated by switching the phone off, then on.

Adaptor to suit Nokia 3310 - XC-5140*
Adaptor to suit Nokia 8310 - XC-5142
Adaptor to suit Nokia 8210 - XC-5144
*XC-5140 requires manual switching also.

ALL TYPES **$14.95**

Camera in a Wrist Watch

Unbelievable as it seems, this wrist watch actually has a built in CMOS camera! It features memory for 40 images, a synthesized voice to announce the functions, and number of shots taken. Watch features include stop watch, alarm, mini spotlight, and it even tells the time. Images are downloaded via the supplied RS-232 cable and viewed using the software supplied on CD-ROM. Compatible with Win95 or later.

BUILT IN CMOS CAMERA

Cat. OC-3362 **$119.95**

FORTIS Recordable DVD's

Great new recordable media at an excellent price!

DVD-R 1x Write Speed

Cat. XC-4730 **$4.95**

DVD-R 4x Write Speed

Cat. XC-4731 **$5.95**

DVD-RW 2x Write Speed

Cat. XC-4732 **$6.99**

DVD+R 2x Write Speed

Cat. XC-4733 **$5.20**

DVD+RW 2x Write Speed

Cat. XC-4734 **$6.99**

4 Port Automatic KVM Switch

This automatic keyboard, video / monitor (KVM) switch allows the user to connect 4 PC's to the one monitor, keyboard and mouse, switching between machines using manual push button or hot keys.

Features:
- PS/2 Mouse and Keyboard emulation.
- Keyboard and mouse can be hot plugged at any time.
- Supports DOS, Win 3.X, Win 95/98/98SE/2000, Me, NT, Netware, Unix and Linux.

DUE LATE DECEMBER

Cat. YN-8096 **$149.95**

2 Way Monitor Splitter

The video splitter takes the computers video signal and sends it to two analogue monitors. Ideal for test bench applications, presentations etc. Supports VGA, SVGA, XVGA and Multi-Sync. •Input 15 pin D male. •Outputs 15 pin D female. •350 MHz video bandwidth. •Max resolution 2048 x 1536 @ 60Hz. •Size: 72(W) x 43(H) x 121(L)mm.

Cat. YN-8098 **$99.95**

8 in 1 USB Card Reader

This unit is the ultimate media card reader, it supports Compact Flash, IBM Micro Drive, Smart Media, Memory Stick, Memory Stick Pro, Memory Stick Duo, Secure Digital, and Multimedia memory cards. USB connection. See website for details.

Cat. XC-4852 **$69.95**

Multimedia Headset

A lightweight adjustable headband, and a small boom style microphone, which can rotate up out of the way. Terminated to 2 plugs, one for mic, and one for headphones.

Cat. AA-2028 **$14.95**

A4 Magnetic Inkjet Paper

Print pictures of you family and friends and stick them on the fridge! You can even get creative and start making your own fridge magnets. 5 A4 sheets included.

Cat. LM-1630 **$19.95**

Surface Mount Memory Card Sockets

Ideal for development and hobbyist applications, or even repairing existing units. See our website for full data sheets.

Multimedia Card	**Cat. PS-0020 $3.95**
Memory Stick	**Cat. PS-0022 $3.95**
Secure Digital	**Cat. PS-0024 $3.95**
XD Card	**Cat. PS-0026 $4.95**
Smart Media	**Cat. PS-0028 $4.95**
Compact Flash	**Cat. PS-0030 $5.95**
4 in 1 – MMC, SD, Memory Stick, Smart Media	**Cat. PS-0032 $14.95**

USB Mini Optical Mouse

Measures only 82 x 35 x 32mm, features optical technology, and a scroll wheel.

Cat. XH-3127 **$34.95**

High Quality Multimedia Speaker System with Subwoofer

Excellent sound from a small unit. It has enough power to rival a Hi-Fi system. Total system power 40WRMS. See website for details.

Cat. XC-5168 **$79.95**

USB Key GSM SIM Card Reader

Super small size, it allows you to read, write, and edit all information stored on your SIM card using your PC. Drivers and software supplied for Win98, 2000, ME.

Cat. XC-5102 **$49.95**

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NEW 40 Channel UHF CB Band Transceivers

0.5W Transceiver with CTCSS – Sub Channel Calling

Continuous Tone Coded Squelch System (CTCSS) is an advanced feature, which effectively allows groups of users to operate their transceivers in 'mute' mode, and only respond to messages from other users using the same CTCSS channel. The system does not provide private use of the channel, as all users on the channel can hear any conversation; however the specific CTCSS equipped transceivers can "page" each other without interfering with general traffic. The unit is compact, lightweight, and boasts a range up to 5km line of sight.

- Uses 4 x AAA batteries (not supplied)
- 38 sub call channels.
- No licence required.
- See website for optional accessories.

Cat. DC-1030 $79.95

High Power 1.5W Transceiver

Up to 8km line of sight range! These transceivers are for serious users. They offer a host of features including a backlit LCD, voice activation, key lock, and much more. It is a lightweight, very portable, and with the extra long range, it won't let you down. It is ideal for use in many professional areas such as electrical installation or building, leisure activities such as hiking or climbing, or anywhere constant communication is necessary.

- Uses 4 x AAA batteries (not supplied)
- No licence required.
- High and Low power setting.
- See website for optional accessories.

Maximum Legal Power!

Not available till January

Cat. DC-1040 $119.00

Super High Power Rechargeable Halogen Spotlights

These are the **BRIGHTEST** halogen spotlights we have ever seen. Great for fishing, camping, 4WD'ing, these lights will be seen for kilometres! Words cannot describe just how bright these spotlights are, so drop into your local store for a look!

YOU WILL NEED SUNSCREEN FOR THESE BABIES!

1,000,000 Candlepower

- Internal 6V 4Ah SLA battery.
- Mains and car charger supplied
- 100mm lens dia.

Cat. ST-3300 $34.95

2,000,000 Candlepower

- Internal 6V 4Ah SLA battery.
- Mains and car charger supplied.
- 130mm lens dia.

Cat. ST-3302 $49.95

3,500,000 Candlepower

- Two internal 6V 4Ah SLA batteries.
- Mains and car charger supplied.
- 170mm lens dia.

Cat. ST-3304 $69.95

Turbo Camping Shower

Add a touch of luxury to that outback adventure. Use a bucket of warm water and your vehicles battery, and enjoy a shower no matter how far from civilisation you are.

Cat. YS-2800 $27.50

4 in 1 Rock Climbing and Hiking Altimeter

This altimeter is capable of measuring from sea level, to 5000m, and doubles as a barometer.

It features a rugged aneroid type mechanism with 50mm adjustment bezel.

See our website for details and specs.

Cat. QM-7280 $49.95

Car Washer Nozzles with LEDs

Dress up your car with these chrome finished windscreen washer nozzles. They simply screw in place of your old washers and can make a great deterrent when used with a car alarm.

Washer Nozzles with Blue LEDs

Cat. LA-5092 $9.95

Washer Nozzles with Tri Colour LEDs

Cat. LA-5094 $19.95

12VDC Gold Fused Distribution Blocks with Voltage Display

Keep an eye on the supply voltage. They feature a 3 digit LED display to keep you informed at all times.

Wafer Style Fuse Block

1 x 2 gauge in, and 2 indivually fused 4 gauge out.

Cat. SZ-2076 $49.95

NEW

4 Way 5AG Fuse Block

2 x 4 gauge in, and 4 individually fused 8 gauge out.

Cat. SZ-2077 $49.95

Non-Slip Car Mat

This handy non-slip mat will keep small items in place like your mobile phone and sunglasses on your car dashboard. It has endless uses and is washable.

Pack of 2

- Measures 170 x 100mm

Cat. QG-2250 $5.95

Replace Your Incandescent Lamps with LED Style Globes!

LEDs are much more efficient, and less fragile than filament globes. LEDs mounted on standard Bayonet, Miniature Edison Screw (MES), and MR16 Halogen bases provide excellent replacements in many applications, consuming less power and lasting much longer. See our website for individual details.

6 x White LEDs on MES base - 6V.	ZD-0300 $19.95
6 x White LEDs on Bayonet base - 12V.	ZD-0302 $21.95
12 x White LEDs on MES base - 6V.	ZD-0304 $21.95
12 x White LEDs on Bayonet base - 12V.	ZD-0306 $27.95
3 x White LEDs on MES base - 12V	ZD-0310 $9.95
12 White LEDs on MR16 (Halogen Type) base 12V	ZD-0315 $29.95
12 x Red LEDs for Car Tail Lamp - 12V	ZD-0312 $18.95
12 x Amber LEDs for Car Indicators - 12V	ZD-0314 $19.95

Stock Up on Rechargeable Ni-MH Batteries for Christmas

Don't get caught with great toys but no batteries!

AAA 800mAh			
Cat. SB-1720	**1+ $3.59**	**10+ $3.15**	**25+ $2.75**
AA 1200mAh			
Cat. SB-1730	**1+ $2.95**	**10+ $2.60**	**25+ $2.30**
AA 2000mAh			
Cat. SB-1706	**1+ $5.95**	**10+ $5.25**	**25+ $4.95**
C 4500mAh			
Cat. SB-2429	**1+ $14.95**	**10+ $13.35**	**25+ $11.70**
D 8000mAh			
Cat. SB-2449	**1+ $22.35**	**10+ $19.70**	**25+ $17.90**

Universal Ni-Cd / Ni-MH Battery Charger

Charges AAA, AA, C, D, and 9V (8.4V) batteries. It features a discharge function, and even a battery tester for 1.2V and 1.5V batteries. See website for details.

Cat. MB-3505 $28.95

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Hung Chang 20MHz Dual Channel, 4 Trace Oscilloscope

A great dual channel oscilloscope designed for the professional and enthusiast alike. Housed in a pressed steel cabinet with heavy duty feet and comprehensive control panel, it is a great, high quality unit. It features a large 6" screen, zero parallax graticule to eliminate reading errors, TV sync for stable synching of video signals, and high sensitivity input amplifiers for measurement down to 1mV/div. See our website for a huge list of features and specifications.

NEW

Cat. QC-1908 **$799**

LCD Vernier Type Engineers Caliper

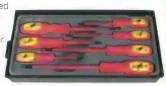
This precision instrument is made from surgical grade stainless steel and operates in metric or imperial. It features a 5 digit LCD display and 150mm (6") range.

See website for details.

Cat. TD-2082 **$79.95**

1000V – 7 Piece Screwdriver Set

GS and DVE tested and approved to 1000V. They feature red rubber grip handles and insulation right to the tip.



Cat. TD-2022 **$19.95**

Soldering Iron Tip Cleaner/Tinner

The Goot tip cleaner/tinner revitalises and restores tips so there almost as good as new. It contains solder powder, and non corrosive flux, so it cleans and tins your tip at the same time. Supplied in a 15g tin, it also has double sided tape, so you can stick the tin to your work bench or soldering station

goot

Cat. TS-1512 **$6.50**

NEW

3.6V Cordless Screwdriver with Pivoting Handle

Nothing beats the convenience of a cordless screwdriver when you have numerous screws to install or remove from a job. It features a powerful motor, forward & reverse switch, safety power lock, 6 torque settings and reversible Philips/Flat driver bit. See website for details.

NEW

Cat. TD-2495 **$19.95**

Programmable Digital LCD Soldering Station

This great iron features excellent temperature stability, rapid heat recovery, 3 programmable preset temperatures, and temperature adjustment between 150°C and 450°C. See website for details.

Was $199

Cat. TS-1400 **$139.00**

Save $60

Cable Tie Gun

Beats wearing out your finger! Featuring a tension adjustment for different cable ties, just slidethe gun over the tie, and pull the trigger for a neat,professional finish.

NEW

Cat. TH-2600 **$19.95**

Heavy Duty Stripper / Cutter / Crimper

This great tool makes light work of wire stripping and cutting. It also crimps insulated terminals.

See website for details.

Cat. TH-1827 **$25.95**

High Quality 5.5" Electrical Shears

These shears offer impressive cutting ability with finely honed and serrated blades. Great for cutting insulation, heatshrink, spaghetti tubing, and light duty hook-up wire.

NEW

Cat. TH-1758 **$9.95**

250VA 240-115VAC Stepdown Transformer Bargain

250W stepdown transformer with dielectric electrical isolation. Quantities strictly limited, don't miss out. Personal shoppers only. Not available through Techstore. Not available in NZ.

NORMALLY RETAILS FOR $129

Cat. MF-1083 **$99**

240V 120W Garden Lighting Transformer Bargain

Supplies 12V at 10A. Will power 6 x 20W, or 2 x 50W and 1 x 20W halogens. Quantities strictly limited, don't miss out. Personal shoppers only. Not available through Techstore.

BARGAIN

Cat. MF-1040 **$45**

Precision Mini Metal Lathe Deal

Industrial quality on a hobby budget! Small hobby lathes are not new, they have been European made and very expensive, or have welded frames and are flimsy. This fantastic unit has a FULL cast iron bed, frame and headstock assembly, just like industrial lathes.

It bristles with safety features including a plastic chuck cover which must be down for the machine to operate. This prevents you from starting the lathe with the chuck-key in! We have not seen a product of this quality at this price. See our website for full features and specifications.

The cutting tools, drill chuck and live centre are all usually sold extra, costing up to $150 more, but are included in the price!!!

Cat. TL-4000 **$899**

The lathe is not on display at all stores but is usually in stock. Mail order / Techstore customers, get a quote for road freight.

Optional Extra Floor Stand

Cat. TL-4002 **$89.95**

Replacement Parts & Accessories: Watch this space for future developments.

Full Instruction Manual: We have made available on our website, the full instruction manual for download. This will help you make the most informed purchasing decision possible.

Soldering Kit

Great starter pack! Includes a 25W Duratech soldering iron, quality stand and sponge, solder, and a desolder wick.

Cat. TS-1650 **$31.95**

Mini Gas Soldering Iron

Great portability for small jobs on the run. If features adjustable temperature, and by removing the tip, you have a handy flame torch.

Cat. TS-1110 **$29.95**

11pc Cellular Phone Toolkit

Includes the essential tools to disassemble and reassemble most mobile phones.

Cat. TD-2024 **$29.95**

Vacuum Bench Vice with 75mm Jaw

A multi positional ball swivel allows the jaw's working position to be varied by 360°. High quality die-cast aluminium.

Cat. TH-1766 **$57.95**

OVER 5,500 PRODUCTS IN STORE
JAYCAR ELECTRONICS

OVER 5,500 PRODUCTS IN STORE JAYCAR ELECTRONICS

AC/DC Current Clamp Meter Kit for DMM's

Ref: Silicon Chip September 2003.
A great low cost alternative to expensive current clamp meters. It uses a simple hall effect sensor, and iron-ring core setup, and connects to your digital multimeter. It will measure AC and DC current, and has a calibration dial to allow for any magnetising of the core. Much cheaper than pre-built units. Kit supplied with PCB, clamp, case, silkscreened front panel and all electronic components.

Cat. KC-5368 **$34.95**

50MHz Frequency Meter Kit

- Ref: Silicon Chip October 2003.
- Very accurate, large 8 digit display.
- Kit supplied with PCB, laser cut silk screened panel, pre-programmed micro, and all specified electronic components.

Cat. KC-5369 **$69.95**

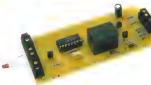
Serial PIC Programmer Kit

- Ref: Silicon Chip September 2003.
- Supports standard and 'in circuit' PIC programming.
- Kit supplied with PCB, and all electronic components.

Cat. KC-5367 **$39.95**

Driving Light Protector Kit

- Ref: Silicon Chip Sept 02.
- Protect your driving lights against theft.
- Triggers alarms or sirens.
- Kit supplied with PCB and all electronic components.



Cat. KC-5337 **$24.95**

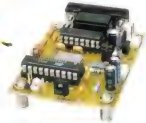
Deluxe Solar Education Kit

A series of experiments to acquire a basic knowledge of solar energy. Includes Solar cell, musical unit, plastic lamp, motor accessories, and plastic adaptors.

Cat. KJ-6694 **$24.95**

PC IR Interface Kit

- Ref: Silicon Chip August 2003.
- Interface with popular PC based DVD and MP3 player software.
- Kit supplied with PCB, and all electronic components.



Cat. KC-5366 **$39.95**

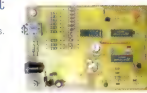
Sunset Switch – Upgraded Version of Silicon Chip Design

Ref: Silicon Chip June 2003.
Switches on mains power at a preset darkness level. We have upgrade this kit from the original Silicon Chip design to switch 240V/10A from the original 240V/6A design. Kit supplied with PCB, electronic components, silkscreened front panel.

Cat. KC-5359 **$79.95**

Digital Reaction Timer Kit

- Ref: Silicon Chip June 2003.
- Great fun for testing against your friends.
- Requires a digital multimeter.
- Kit supplied with PCB and all electronic components.



Cat. KC-5360 **$29.95**

YOUR LOCAL JAYCAR STORE

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Bankstown	•Ph (02) 9709 2822
Bondi Junction	•Ph (02) 9369 3899
Brookvale	•Ph (02) 9905 4130
Campbelltown	•Ph (02) 4620 7155
Erina	•Ph (02) 4365 3433
Newcastle	•Ph (02) 4965 3799
Parramatta	•Ph (02) 9683 3377
Penrith	•Ph (02) 4721 8337
Silverwater	•Ph (02) 9741 8557
St. Leonards	•Ph (02) 9439 4799
Sydney City	•Ph (02) 9267 1614
Wollongong	•Ph (02) 4226 7089
VICTORIA	
Coburg	•Ph (03) 9384 1811
Frankston	•Ph (03) 9781 4100
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Melbourne	•Ph (03) 9663 2030
Ringwood	•Ph (03) 9870 9053
Springvale	•Ph (03) 9547 1022
QUEENSLAND	
Aspley	•Ph (07) 3863 0099
Brisbane - Woolloongabba	•Ph (07) 3393 0777
Gold Coast - Mermaid Beach	•Ph (07) 5526 6722
Townsville	•Ph (07) 4772 5022
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Hobart	•Ph (03) 6272 9955
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Freecall Orders	•Ph 0800 452 9227

Short Circuits by Jaycar ELECTRONICS

LEARNING ELECTRONICS IS FUN!

Short Circuits 1

Some of the exciting projects include a Police Siren, Electronic Organ, Sound Effects Unit, Light Chaser and a Solar Powered Radio. Many more projects are included! Remember, no prior knowledge of electronics is needed and the projects are totally safe. This volume will teach you everything you need to get started in electronics and is suitable for ages 8+. Kits contain small parts.

Cat. EJ-8502 **$14.25**

Short Circuits, Volume 2

Graduate to printed circuit board kit construction. Soldering is not for 8 year olds but its fine if you are older or are under adult supervision. In Short Circuits II we teach you how to solder. We teach you a lot else as well! Such as:

- How to use a Multimeter
- What tools you will need.
- How the circuit works (Tech talk).

There are over 20 projects in this book. We don't have room to describe them all here, so this is a summary:

- Red/Green flasher
- "Skeet" shooting game
- "Touch" switch
- Tester for Capacitors and Resistors
- Sound level meter
- Event counter, 0 – 999
- Metronome

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Short Circuits 3

Like our Volumes 1 & 2 book, Short Circuits Volume 3 is sold independently to each of the 30-odd projects. Some of the projects you will build include a Guitar Sustain Unit, a Universal Timer, Car Alarm, Two Lamp Flasher plus many more! Building the projects described in Volume 3 will provide you with the confidence needed to tackle more complex projects.

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PRODUCT SHOWCASE

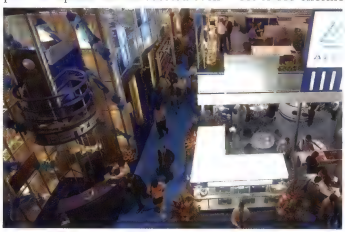
Hong Kong Electronics Show bounces back from SARS

In spite of the big setback from SARS earlier in the year, Hong Kong has bounced back in a big way to host a very successful electronics trade fair, show-casing products from mainland China and the rest of the world.

Even though the Hong Kong Lighting Fair had been split off into a show of its own, the 2003 electronics trade fair was bigger than last year with 1950 exhibitors and 48,291 buyers.

If that was not enough, the atmosphere of optimism was boosted even further by the announcement of the CEPA (Closer Economic Partnership Arrangement). This is a free trade agreement between Hong Kong and China which represents a significant market liberalisation and preferential access to China's market for all companies incorporated and operating in Hong Kong.

No doubt Hong Kong (Kowloon), presently the world's second biggest harbour and container terminal, is set to see enormous growth in years to come.



While a great deal of the show was devoted to domestic electrical and electronic equipment, there was an astonishing range of electronic equipment of all types, as well as a very diverse range of semiconductor and passive electronic componentry.

Some of the interesting new stuff included organic LED displays (See SILICON CHIP, August 2003), all sorts of digital cameras, MP3 players, USB storage and peripheral items, 2.4GHz video/audio links and a wide range of mobile phone and Bluetooth accessories.

As was the case in 2002, Hong Kong never fails to impress with the vitality of its people and its economy and the general impression that everything is possible and "will be done".

Fujifilm's USB 'Thumb' Drive

Fujifilm has introduced the xD Picture Card USB 'Thumb' drive – an ultra compact USB card reader that can be used exclusively with the xD Picture Card which comes as an accessory with every Fujifilm FinePix digital camera.

The $59.95 (rrp inc GST) pocket-sized USB card reader inserts directly into a personal computer's USB slot enabling images to be easily saved on a PC without any major procedures. It eliminates the need to connect your entire camera to a computer – instead it allows you to use the card as if it were part of your computer.

In addition to capturing photos, the xD Picture Card can also store presentations, reports or any other documents which can then be conveniently uploaded to a computer.

The drive is compatible with all Fujifilm xD Picture Cards currently available, ranging in size from 16MB up to 512MB.

No driver software is required for Win ME, 2000, XP or Macintosh systems. Driver software for Win 98 or 98SE can be downloaded from the Fujifilm Worldwide Website at www.fujifilm.com

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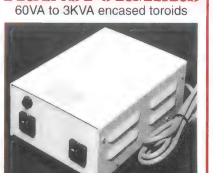

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AV Switching Unit for Home Theatre

With so many AV sources these days – DVD players, VCRs, game consoles, satellite receivers and so, what happens if you run out of AV inputs on your TV or Home Theatre system?

You're faced with two options – the expense of buying another unit that can handle more inputs or be constantly forced to pull cables in and out of equipment which is not only an inconvenience but over time it can damage plugs and leads.

The new A-3070 remote control switcher from Altronics could be a simple inexpensive solution. It can add 3 more inputs to your system and let you to switch between them (via remote or front panel).

It features input connections for connectors for SVHS, optical and RCA making it suitable for most common connections in modern hi-fi and home theatre systems.

The A-03070 is not only versatile for hi-fi installs it could also be used to connect security cameras to your television. It's a cheap and effective way of installing your own video surveillance.

The A-3070 has an RRP of $149 and is available from Altronics directly or one of their dealers around the country.

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website: www.altronics.com.au

Disaster Recovery from PowerQuest

Many small businesses lack the enterprise-class machine room environments and expensive robotic tape libraries which are viewed as essential to best-in-class data protection. Others may have small IT budgets or have implemented backup solutions that may not provide sufficient protection. Because of this, small businesses are at risk of critical system outages and data loss

PowerQuest Corporation, a global provider of deployment and recovery solutions, announces PowerQuest V2i Protector 2.0 Small Business Edition, the latest version of its popular disk-based backup and disaster recovery solution for Windows servers.

V2i Protector 2.0 Small Business Edition creates compressed backup images of a server's volumes—including operating system, server settings and preferences—that can be used to restore system and data volumes, or individual files and folders, in minutes, as opposed to the hours it can take using traditional backup methods. Windows NT, 2000, 2003 and Small Business Server are supported, giving small to medium-size businesses an easy-to-use and more affordable solution to automate system and data protection.

Backup images can be saved directly to any network storage device such as a RAID array, NAS or SAN. It can also mount backup image files as read-only network or workstation drives that can be shared to other network users.

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Level 67, MLC Centre Martin Place
Sydney, NSW 2000
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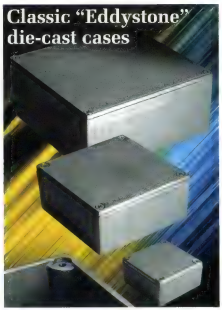
website: www.powerquest.com

Classic "Eddystone" die-cast cases



World-famous "Eddystone" die-cast cases are now being marketed in Australia by Hammond Electronics, one of the world's leading manufacturers of small die-cast aluminium and plastic enclosures.

Probably one of the best known brands in the small enclosure sector, the Eddystone range consists of nine sizes of thin wall, shallow lid, general purpose die-cast aluminium enclosures and a further five variants fitted with a deep lid.

Hammond's Australian operation is a manufacturer in its own right and has introduced a further three Australian-designed and manufactured cases to complement the original 14-strong family. The new sizes are 50 x 50 x 21, 92 x 92 x 38 and 125 x 125 x 53mm.

Contact:
Hammond Electronics
GPO Box 812, Adelaide, SA 5001
Tel: 08 0825 0744 Fax (08) 9356 3652
website: www.hammondmfg.com

A PC for $39?

No, it's not a misprint! You can buy a real, live, operational PC for just $39.00 from Oatley Electronics. You get a full 366MHz Celeron computer system with just about everything you need except memory, hard disk and a case. It even has a dual redundant power supply, a CD-ROM drive and a Sound Blaster Vibra 16X sound card. Most of those on their own would cost you more than $39!

OK, so they're not brand new – Oatley describe them as "hardly used" – but waddya expect for under forty bucks?

Needless to say, with no hard disk there is no operating system or drivers. And they're while stocks last!

Contact:
Oatley Electronics
Tel: 02 9584 3563 Fax: 02 9584 3561
website: www.oatleyelectronics.com

SILICON CHIP WebLINK

How many times have you wanted to access a company's website but cannot remember their site name?

Here's an exciting new concept from SILICON CHIP: you can access any of these organisations instantly by going to the SILICON CHIP website (www.siliconchip.com.au), clicking on WebLINK and then on the website graphic of the company you're looking for. It's that simple. No longer do you have to wade through search engines or look through pages of indexes – just point'n'click and the site you want will open!

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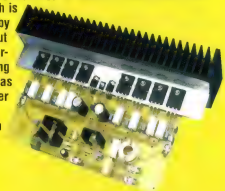
COMING NEXT MONTH: "World Class" Power Amplifier

Following the outstanding success of our SC480 power amplifier module published in January & February 2003, we've taken some of the lessons learned there and from our Ultra-LD series and applied them to a much bigger power amplifier which pushes the performance boundaries to new limits.

New high voltage low noise transistors make it incredibly quiet, while the eight 250V 200W plastic power transistors allow it to deliver 200 watts into 8 ohms and 350 watts into 4 ohms. Music power is even more impressive: 240 watts into 8 ohms and a massive 480 watts into 4 ohms.

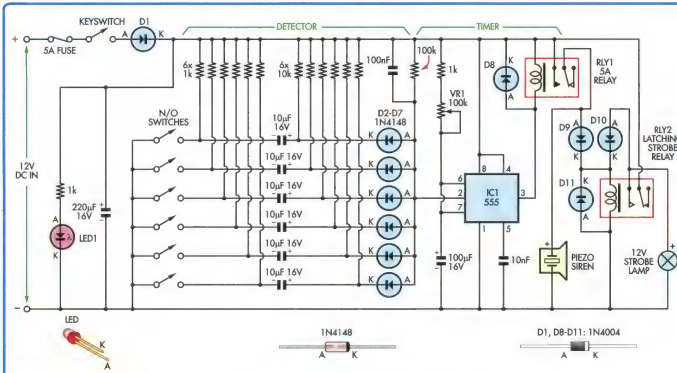
We've also used the best available driver transistors and PC board distortion-cancelling topology to obtain a world-class distortion performance which is easily reproducible, just by following the wiring layout diagrams. In terms of performance per dollar (bang for your bucks), this has to be one of our best ever amplifier modules.

Don't miss this issue, on sale late December.



CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.



Simple 6-input alarm circuit

This simple alarm circuit was designed for use in a combined garage and rumpus room. It can be assembled on Veroboard and uses just one IC plus a handful of cheap components.

The circuit is based on a straightforward 555 timer circuit (IC1). This is wired as a monostable and sets the siren period which is adjustable up to about three minutes using potentiometer VR1.

In operation, IC1's pin 2 input monitors the detector circuit for negative-going signals. When a switch is closed, a brief negative-going pulse is applied to pin 2 via a 10µF capacitor and its corresponding series diode (D2-D7). This triggers IC1 which switches its pin 3 output high and switches off relay RLY1 (ie, RLY1 is normally on).

As a result, the piezo siren sounds for the duration of the monostable period. In addition, relay RLY2 is turned on via diode D9 and latches on via D10. This means that the strobe light (which is wired to the normally open contact) will continue to flash until the alarm is switched off (via the keyswitch).

At the end of the monostable period, RLY1 turns off and this turns off the piezo siren. The circuit can then be retriggered by any further trigger inputs from the switches.

A variety of detectors with normally open contacts can be used for the switches, including reed switches, pressure mats, IR detectors and glass breakage detectors. All switches must be open before the alarm is switched on.

R. Love,
Highbury SA. ($40)

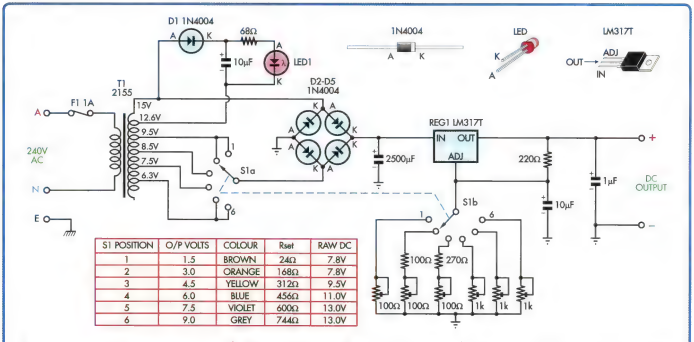
Courtesy light extender

In essence, this circuit is a 15 to 20-second courtesy light extender for cars. It is activated in the usual way by opening a door but it also samples the negative lock/unlock signals from a car alarm or central locking and does two more things.

First, when an unlock signal is received, it turns on the courtesy light for 15-20 seconds before you open the door. Second, when a lock signal is received, it turns off the courtesy light immediately, with no fade-out. This is done to eliminate false triggering of the burglar alarm through current drain sensing.

When a car door is open or the unlock relay is activated, the 33µF capacitor discharges through diode D1 and this keeps transistor Q1 turned off. This allows Q2 and Q3 to turn on and the courtesy lamp is activated.

When the door is closed, the



S1 POSITION	O/P VOLTS	COLOUR	Rset	RAW DC
1	1.5	BROWN	24Ω	7.8V
2	3.0	ORANGE	168Ω	7.8V
3	4.5	YELLOW	312Ω	9.5V
4	6.0	BLUE	456Ω	11.0V
5	7.5	VIOLET	600Ω	13.0V
6	9.0	GREY	744Ω	13.0V

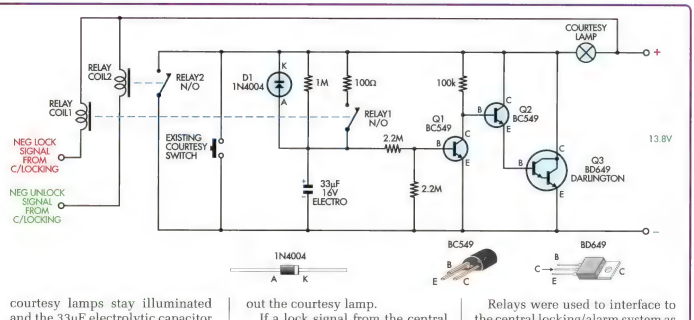
Battery replacement power supply

Your child's battery toy has failed and you have to fix it. Once you have managed to get it apart, the battery compartment is not likely to be connected to the works or the batteries might have gone flat anyway. The solution is this switchable supply which is designed to replace from one to six dry cells. It is not intended to replace the batteries on a permanent basis, as in most cases this is not practical.

The heart of the supply is an LM317T adjustable 3-terminal regulator and six trimpots selected by switch S1b. The other pole of the switch, S1a, is used to select taps on the transformer secondary, to minimise power dissipation in the LM317T. The table shows the trimpot settings for the six voltage outputs.

Diode D1 and the 10µF capacitor and the LED provide power indication. This has the advantage of constant brightness which would not be obtained if the LED was run from the unregulated switchable DC.

Philip Button,
West Moonah, Tas. ($35)

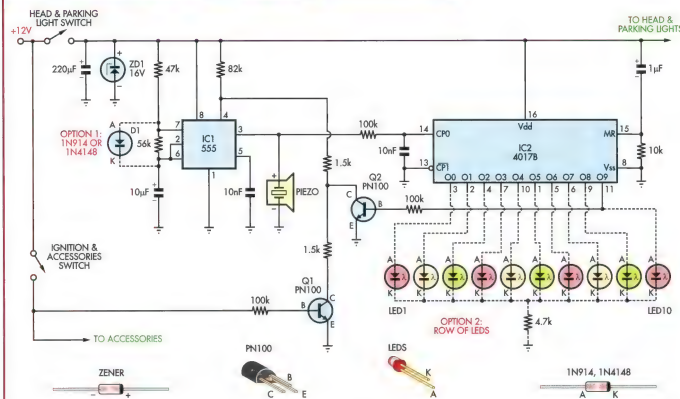


courtesy lamps stay illuminated and the 33µF electrolytic capacitor starts charging through the associated 1MΩ resistor. As the voltages rises, Q1 turns on slowly, turning off Q2 and Q3 which gradually fades out the courtesy lamp.

If a lock signal from the central locking system is received, relay 1 closes and charges the capacitor instantly, so the lamp turns off immediately.

Relays were used to interface to the central locking/alarm system as a safety feature, to provide isolation in case something goes wrong.

Matt Downey,
Marleston, SA. ($35)



Automatic headlight reminder

Do you drive an older car without an automatic "lights-on" warning circuit? If so, you've probably accidentally left the lights on and flattened the battery on one or more occasions.

This headlights reminder circuit will prevent that. It's more complicated than other circuits but it's also more versatile.

As shown, the circuit uses two low-cost ICs. IC1 is a 555 timer which is wired to operate in astable mode. Its output clocks IC2, a 4017B decade counter. IC2 in turn drives a row of indicator LEDs and also resets IC1 (after about 10s) via transistor Q2.

The circuit works like this: when the ignition is on, transistor Q1 is also on and this pulls pin 4 of IC1 low. As a result, IC1 is held reset and no clock pulses are fed to IC2.

Conversely, if the ignition is turned off, Q1 will turn off and so IC1 will start oscillating and sound the piezo siren. At the same time, IC1 will clock IC2 and so LEDs 1-10 will light in sequence and stop (after about 10s) with the last LED (LED10) remaining on. That's because, when IC2's O9 output (ie, pin 11) goes high, Q2 also turns on and this pulls pin 4 of IC1 low, thus stopping the oscillator (and the siren).

Note that different coloured LEDs are used to make the display look eye-catching but you make all LEDs the same colour if you wish. Installing optional diode D1 will alter IC1's frequency and this will alter the display rate.

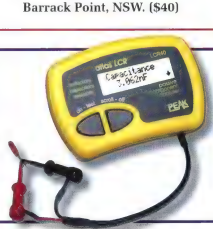
Finally, if the lights are turned off and then back on again, the alarm will automatically retrigger. LED1 is always on if the lights are turned on. If you don't want the LED display, just leave the LEDs out.

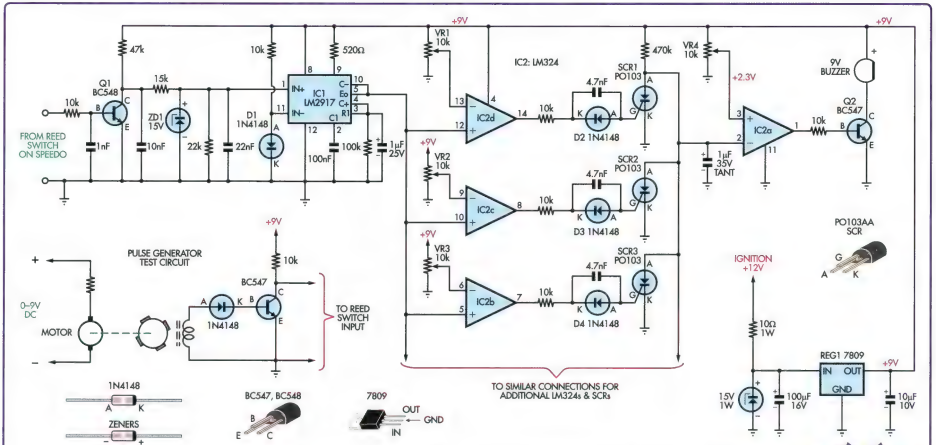
L. Marshall,
Barrack Point, NSW. ($40)

CONTRIBUTE AND WIN!

As you can see, we pay good money for each of the "Circuit Notebook" contributions published in SILICON CHIP. But now there's an even better reason to send in your circuit idea: each month, the best contribution published will win a superb Peak Atlas LCR Meter valued at $195.00.

So don't keep that brilliant circuit secret any more: sketch it out, write a brief description and send it to SILICON CHIP and you could be a winner!





Speed alarm for cars

In normal suburban driving you pass through so many different speed zones that it can be a nuisance having to switch speed settings. The speed display can also be a distraction. This circuit eliminates the display and the need for speed selection. Each time you exceed a particular speed setting (eg, 40km/h, 50km/h, etc), a piezo buzzer will beep.

Speed pulses are fed to the base of Q1 and the resulting waveform at its collector is fed via an RC network to the input of an LM2917 frequency-to-voltage converter, IC1. The resulting voltage is fed to three comparators (IC2d-IC2b) which have the reference voltages at their inverting inputs set by 10-turn trimpots VR1, VR2 & VR3.

The output of each comparator is applied via another RC network to the gate of an SCR. The anodes of the three SCRs are commoned connected to the inverting input of the remaining comparator, IC2a. Its non-inverting input is set to +2.3V by trimpot VR4.

In use, once you exceed the speed setting for a particular comparator, its associated SCR briefly conducts to pull pin 2 of IC2a low and a short beep is emitted by the piezo buzzer. Then, as you exceed the next speed setting, another beep will be heard.

The idea is make each speed setting a few km/h higher than actual so that if you are driving at the correct speed in a given zone, the buzzer will not sound. But as you increase speed, the buzzer will beep once as you exceed the speed setting for each zone.

Col Edwards is this month's winner of the Peak Atlas LCR Meter

In this way, there is no need to continually switch speed settings as you drive through different zones and you can choose to ignore beeps that are not "illegal".

Col Edwards,
Rosslea, Qld.

PC BOARD DESIGN TUTORIAL

In this third part of our short PC board design feature, we look at the "other layers" which make up a PC board, along with more advanced layouts and ways to make your board acceptable to manufacturers.

Part 3 – by David L. Jones

If you ask most hobbyists and even many professionals what constitutes a PC board, they'd probably say the copper tracks and the base on which they are etched. But there is often much more to a PC board than that. For a start, there are other layers. And we are not just talking about double-sided or multi-layer boards, either.

Silk screen

The "silk screen" layer is also known as the "component overlay" or "component layer". It is the layer on the top of your board (and bottom if needed) that contains the component outlines, designators (C1, R1 etc) and free text. This is printed on your board using a silk screening process. White is a standard colour but other colours are available upon request. You can even mix and match colours on the one board but that usually costs extra.

When designing your board, make sure that you keep all your component designators the same text (font) size and oriented in the same direction. When laying out your own component footprints, where possible, make sure that you add a component overlay that reflects the actual size of your component. This way you will be able to tell at a glance how close you can physically position your components. Ensure that all polarised components are marked and that pin 1 is identified.

Your silk screen layer will be the most inaccurately aligned of all your layers, so don't rely on it for any positional accuracy. Ensure that no part of the silk screen overlaps a bare pad. Apart from printing limitations and readability, there is no minimum width requirement for lines on the component overlay, so feel free to use smaller lines and text sizes to fit things in. If parts of the text or lines don't turn out perfectly on your board then it does not affect your design, unlike tracks and pads.

To avoid clutter, some designers don't put component values on the silk screen, just the component designator. SILICON CHIP takes the opposite approach and uses the component values, not designators. This latter approach means that anyone checking the board does not have to refer back to the circuit or parts list to find the component values.

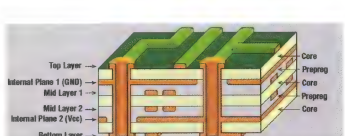
Solder Mask

A solder mask is a thin polymer coating on the board which covers everything except the pads, and helps prevent solder from bridging between pins and tracks.

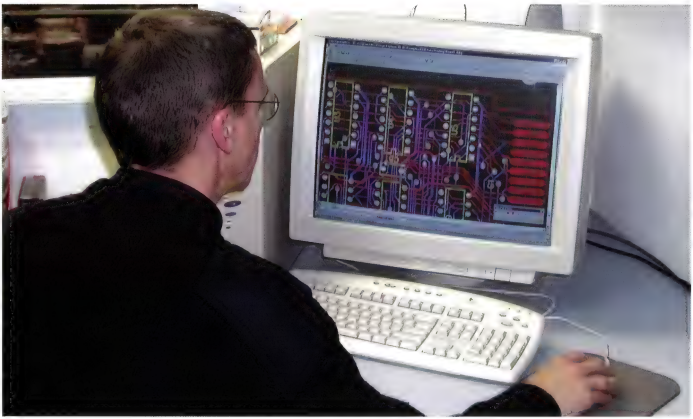
This is essential for surface mount and fine pitch devices. Your PC board program will automatically remove solder mask from the pads.

The gap it leaves between the pad and the solder mask is known as the "mask expansion". The mask expansion should usually be set to at least a few thou. Be careful not to make it too big or there might be no solder mask between very fine pitch devices.

Your solder mask is displayed in your PC board package as a negative image, just like the power plane. Under normal circumstances you don't



"Inside" a multi-layer PC board – in this case, four layers. Note the "vias" which connect all the layers together.



need to put anything on your solder mask layer.

But if you want to leave the solder mask off a certain part of your board, you can place tracks and fills on your solder mask layer.

Solder masks come in two types, silk screen or "photo imageable". Photo imageable masks provide better resolution and alignment and are preferred over silk-screened. You can get different colour solder masks but the standard colour is green.

On most standard quality boards, the solder mask is laid directly over the bare copper tracks. This is known as Solder Mask Over Bare Copper or SMOBC. You can get other coatings over your tracks in addition to the solder mask but these are usually for fairly exotic applications.

Mechanical Layer

The mechanical layer (which may go under other names depending on the package) is used to provide an outline for your board and other manufacturing instructions.

It is not part of your actual PC board design but is very useful to tell the PC board manufacturer how you want your board assembled. There are no hard and fast rules for this layer. Use it however you like; just make sure you tell your PC board manufacturer.

Keepout

The keepout layer generally defines areas on your board that you don't want auto or manually routed. This can include clearance areas around mounting hole pads or high voltage components, for instance.

Layer Alignment

When the PC board manufacturer makes your board, there will be alignment tolerances on the artwork film for each layer. This includes track, plane, silkscreen, solder mask and drilling. If you don't allow for this in your design and make your tolerances too fine, you can end up in big trouble.

Consult the manufacturer for what alignment tolerances they can achieve, and also what alignment tolerance you are paying for!

Netlists

A netlist is essentially a list of connections ("nets") which correspond to your schematic. It also contains the list of components, component designators, component footprints and other information related to your schematic. The netlist file can be generated by your schematic package.

Generating a netlist is also called "schematic capture".

Your PC board package can then import this netlist file and do many things. It can automatically load all the required components onto your blank board. It can also assign a "net" name to each of your component pins. With nets assigned to your PC board components, it is now possible to Auto Route, do Design Rule Checking and display component connectivity. This is the fundamental concept behind modern Schematic and PC board CAD packages.

Rat's Nest

Your job of component placement will be made infinitely easier by having a "rats nest" display enabled. If there is one reason for going to the trouble of drawing up an accurate schematic and importing a netlist, this is surely it. For large designs, a rat's nest display is essential.

A rat's nest display is one where the program will draw a straight line (not a track) between the pads of components which are connected on the schematic. In effect, it shows the connectivity of your circuit before you start laying out tracks. At the start of your board layout, with all your components placed down randomly, this will appear as a huge and complicated random maze of

lines. Hence the name "rat's nest".

The rat's nest may look very daunting at first but when you move each component the lines will automatically move with them. In this way you can see instantly which components are connected to which, without having to refer back to the schematic and constantly cross-reference component designators. Once you have used this feature, you won't want to live without it

With the rat's nest display enabled, it will be almost possible to lay out all of your components optimally in no time, without having to lay down one single track. The rat's nest display will effectively show you what your tracks will connect to. The rat's nest lines should disappear when you route your tracks between components, so your design will get less and less "complicated looking" as you go along. When all the rat's nest lines disappear, your board is fully routed.

Design rule checking

Design Rule Checking (DRC) allows you to automatically check your PC board design for connectivity, clearance and other manufacturing errors. With the large and complex PC boards being designed today, it is impractical to manually check a PC board design. This is where the DRC comes into its own; it is an absolutely essential step in professional PC board design.

Examples of what you can check with a DRC are:

- Circuit connectivity. It checks that every track on your board matches the connectivity of your schematic.

- **Electrical clearance**. You can check the clearance between tracks, pads and components.

- Manufacturing tolerances like min/max hole sizes, track widths, via widths, annulus sizes and short circuits.

A complete DRC is usually performed after you have finished your PC board. Some packages even have the ability to do "real time" (or "online") DRC checking as you create your board. For instance, it won't let you connect a track to a pad it shouldn't go to, or violate a clearance between track and pad. If you have real-time DRC capability, use it; it's an invaluable tool.

Forward and back annotation

Forward Annotation is when you make changes to your existing PC board layout via the schematic editor. The program will take your schematic netlist and component designators and import them into your PC board design and make any relevant changes. Some packages will also automatically remove old PC board tracks that are no longer connected. You can do this at any time during your PC board layout. If you update your schematic, then you must forward annotate into your PC board design. You can do edits like this manually but forward annotation automates the process.

Back Annotation is when you change one of the component designators (eg, C1 to C2) on your PC board and then automatically update this information back into your Schematic. More advanced back annotation features allow you to swap gates on chips and perform other electrical changes. There should never be much real need to use back annotation.

Multi-layer PC board design

A multi-layer PC board is much more expensive and difficult to manufacture than a single or double-sided board but it really does give a lot of extra density to route power and signal tracks. By having signals running on the inside layers of the board, you can pack components more tightly to give a more compact design.

Deciding to go from double-sided to multi-layer can be a big decision, so make sure that a multi-layer board is warranted on the grounds of board size and complexity. You can forget about making multi-layer boards yourself - it requires a commercial manufacturer. Most of the hobby board suppliers will not do multi-layer boards.

Multi-layer boards come in even numbers of layers, with 4, 6 and 8-layer being the most common. With a multi-layer board, you would typically dedicate one layer to a ground plane and another to your power, with perhaps a few signal tracks thrown on the power layer if you need to. If you have a digital-only board, then you'd often dedicate the entire power layer also. If you have room on the top or bottom layer, you can route any additional power rail tracks on there. Power layers are almost always in the middle of the board, with the ground closer to the top layer.

Once you have your power taken care of on the inner layers, you'll be surprised at the room you now have available for your signal tracks. It really does open up a whole new dimension to routing.

If power planes are vital and you have a lot of connections to route, then you may have to move from four to six layers. Six layers will give you four full signal routing layers and two layers dedicated to power. You can really do some advanced routing with six layers. Eight layers and above is basically more of the same.

Multi-layer design brings the options of using different types of vias to improve your routing density. There are three types of vias - standard, blind and buried. Standard vias go through the whole board and can connect any of the top, bottom or inner layers. These can be wasteful of space on layers which aren't connected. "Blind" vias go from the outside surface to one of the inner layers only. The hole does not protrude through the other side of the board. The via is in effect "blind" from the other side of the board. "Buried" vias only connect two or more inner layers, with no hole being visible on the outside of the board. So the hole is completely buried inside your board.

Blind and buried vias cost more to manufacture than standard vias. But they are very useful and almost mandatory for very high-density designs like those involving Ball Grid Array (BGA) components.

Power planes

It is good practice to use "power planes" to distribute power across your board. Using power planes can drastically reduce the power wiring inductance and impedance to your components. This can be vital for high-speed digital design, for instance. It is good design practice to use power planes whenever possible. They can even be used on double-sided boards, if most of your signal tracks are on the top layer.

A power plane is basically one solid copper layer of board dedicated to either the Ground or Power rails, or both. Power planes go in the middle layers of the board, usually on the layers closest to the outer surfaces. On a 4-layer board with complex power requirements, it is common to dedicate one layer to the ground plane and another layer to various positive and negative power tracks. The ground rail

is usually your signal reference line, so a ground plane is first preference before a power plane is considered.

Many PC board packages have special Power Plane layers that are designed and laid out in reverse to the other normal tracking layers. On a normal tracking layer, your board is assumed to be blank and you then lay down tracks which will become your actual copper tracks. On a power plane however, your board is assumed to be covered with copper. Laying down tracks on a power plane actually removes the copper. This concept can take some getting used to.

A simple power plane will not have any "tracks" (or removed copper bits) at all on it but will just be one solid layer of copper. In which case you don't need to lay down any tracks to remove any copper. However, it is common practice on more complex boards to "split" the power plane by laying down tracks. This may be done to separate an analog and a digital ground, which will reduce the amount of digital ground noise which is coupled into the more sensitive analog circuitry. A typical split power plane would involve a "track" being placed from near your input power connector or main filter capacitors and the opposite edge of the board. Be careful not to accidentally cause a power "loop" on your board by inadvertently connecting the two halves of your plane on the other side of the board.

As a matter of course, you should place "tracks" completely around the outer edge of your board. This will ensure that the power planes do not extend right to the edge of the board. Power planes on the edges of your board can not only short to one another but also to any guide rails or mounting hardware.

You don't have to use the actual Power Plane layer on your PC board package if you don't want to. You can use a regular signal layer and lay down copper fills and tracks yourself. Power Planes layers though often have some advantages that will vary from one PC board package another.

Good grounding

Grounding (or earthing) is fundamental to the operation of many circuits. Good or bad grounding techniques can make or break your design. There are several grounding techniques which are always good practices to incorporate into any design.

- Use copper, and lots of it. The more copper you have in your ground path, the lower the impedance. This is highly desirable for many electrical reasons. Use polygon fills and planes where possible.
- Always dedicate one of your planes to ground on multi-layer boards. Make it the layer closest to the top layer.
- Run separate ground paths for critical parts of your circuit, back to the main filter capacitor(s). This is known as "star" grounding, because the ground tracks all run out from a central point, often looking like a star. In fact, try and do this as matter of course, even if your components aren't critical. Separate ground lines keep current and noise from one component from affecting other components.
- If using a ground plane, utilise "split" plane techniques to give effective star grounding.
- "stitch" required points straight through to your ground plane; don't use any more track length than you need.
- Use multiple vias to decrease your trace impedance to ground.

Good bypassing

Active components and points in your circuit which draw significant switching current should always be "bypassed". This is to "smooth" out your power rail going to a particular device. "Bypassing" is using a capacitor across your power rails as physically and electrically close to the desired component or point in your circuit as possible. A typical bypass capacitor value is 100nF (0.1uF), although other values such as 1uF, 10nF and 1nF are often used to bypass different frequencies. You can even have two or three different value capacitors in parallel.

When bypassing, you CANNOT replace multiple capacitors with one single capacitor; it defeats the entire purpose of bypassing! It is not uncommon for a large design to have hundreds of bypass capacitors.

As a general rule, you should use at least one bypass capacitor per IC or other switching component if possible. Common values of bypass capacitors are 100nF for general purpose use, 10nF or 1nF for higher frequencies, and 1uF or 10uF for low frequencies.

Special low Equivalent Series Resistance (ESR) capacitors are sometimes used on critical designs such as switch mode power supplies.

HF design techniques

High frequency design is where you really need to consider the effects of parasitic inductance, capacitance and impedance of your PC board layout. If your signal is too fast, and your track is too long, then the track can take on the properties of a transmission line. If you don't use proper transmission line techniques in these situations then you can start to get reflections and other signal integrity problems.

A "critical length" track is one in which the propagation time of the signal starts to get close to the length of the track. On standard FR4 copper boards, a signal will travel roughly 15cm every nanosecond. A rule of thumb states that you need to get really concerned when your track length approaches half of this figure. But in reality it can actually be much less than this.

Remember that digital square wave signals have a harmonic content, so a 100MHz square wave has harmonic

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In high-speed design, the ground plane is fundamental to preserving the integrity of your signals and also to reducing EMI emissions. It allows you to create "controlled impedance" traces, which match your electrical source and load. It also allows you to keep signals coupled "tight" to their return path (ground).

There are many ways to create controlled impedance "transmission" lines on a PC board. But the two most basic and popular ways are called Microstrip and Stripline.

A Microstrip is simply a trace on the top layer, with a ground plane below. The calculation involved to find the characteristic impedance of a Microstrip is relatively complex. It is based on the width and thickness of the trace, the height above the ground plane and the relative permittivity of the PC board material. This is why it is important to keep the ground plane as close as possible to (usually) the top layer.

A Stripline is similar to the Microstrip, but it has an additional ground plane on top of the trace. So in this case, the trace would have to be on one of the inner layers. The advantage of stripline over microstrip is that most of the EMI radiation will be contained within the ground planes.

There are many free programs and spreadsheets available that will calculate all the variations of Microstrip and Stripline for you.

Some useful information and rules of thumb for high frequency design are:

- Keep your high frequency signal tracks as short as possible.
- Avoid running critical high frequency signal tracks over any cutout in your ground plane. This causes discontinuity in the signal return path, and can lead to EMI problems. Avoid cutouts in your ground plane wherever possible. A cutout is different to a split plane, which is fine, provided you keep your high frequency signal tracks over the relevant continuous plane.
- Have one decoupling capacitor per power pin.
- If possible, track the IC power pin to the bypass capacitor first, and then to the power plane. This will reduce switching noise on your power plane. For very high frequency designs, taking your power pin directly to the power plane provides lower inductance, which may be more beneficial than lower noise on your plane.
- Be aware that vias will cause discontinuities in the characteristic impedance of a transmission line.
- To minimise crosstalk between two traces above a ground plane, minimise the distance between the plane and trace and maximise the distance between traces. The coefficient of coupling between two traces is given by $1/(1+(\text{Distance between traces / height from plane})^2)$.
- Smaller diameter vias have lower parasitic inductance and are thus preferred for higher frequency circuits.
- Do not connect your main power input connector directly to your power planes; take it via your main filter capacitor(s).

Double-sided loading

Loading components on both sides of a PC board can have many benefits. Indeed, it is becoming an increasingly popular and necessary option when laying out a board.

There are two main driving factors behind a decision to go with double-sided loading. The first is that of board size. If you require a particular board size and all your components won't fit on one side, then double-sided loading is an obvious way to go.

The second reason is that it is required to meet certain electrical requirements. Often these days, with dense high speed surface mount devices packed onto a board, there is either no room for the many bypass capacitors required or they cannot be placed close enough to the device to be effective. Ball Grid Array (BGA) devices, for example, benefit from having the bypass capacitors on the bottom of the board.

Indeed, it is common to find double-sided loaded boards with nothing but bypass capacitors mounted on the back. This allows the bypass capacitor to be as close to the physical device power pin as possible.

Be sure to involve your PC board assembler in discussions during the layout of your board. There are many things you can and can't do with double-sided loading.

Auto routing

"Real PC board designers don't auto route!" is an age-old war cry.

While many will claim this is true, reality may often kick in and there certainly are times when you do need to consider the use of an auto router.

Auto routing is the process of getting the PC board software to route the tracks for you. It will even attempt to route your entire board if you let it.

Most of the medium to top range PC board packages will do this and the technology and theory behind autorouting techniques can be mind-boggling. Artificial intelligence and neural-based technology are some of the marketing buzz words used.

If the PC board program can route the board for you, why not always use it? Doesn't it just automate a mundane process like laying down tracks? The answers can be complicated and many but no matter how "smart" an auto-router is, it simply cannot replace a good human PC board designer. It is like trying to ask a computer program to paint a picture for you. If you give it enough information it may to able to produce something legible but it won't be artistic and certainly won't be a Mona Lisa.

Many people think that auto-routers are a tool to help not-so-experienced PC board designers. In fact, the opposite is true! In the hands of an inexperienced designer, an auto router will produce a complete mess. But in the hands of a very experienced designer, an auto router can produce excellent results much quicker than the human designer could do.

Auto routers come in handy when you have complex boards with not much routing space, on non-critical parts of your layout. Non-critical parts of a board might include low frequency or static control signals to components like LED displays, switches and relays. Advanced auto-routers do come with tools to let you specify exactly how you want electrically important tracks laid out. But by the time you have told it in excruciating detail what to do with every track, you could have laid it out yourself!

Never use an auto-router to do your complete board; it will be a mess. But if you let it loose on a very specific non-critical area of your board, you can get some excellent results, sometimes indistinguishable from manual routing. You can even auto-route a single connection, and this is sometimes handy when you are having trouble finding routing space in the final phase of your layout.

Unless you are very experienced at PC board design, simply stay away from auto-routers. This cannot be stressed enough.

Auto Placement

Auto Placement tools are available in many higher end PC board packages. Professional PC board designers do not use Auto Placement tools; it's that simple. Don't rely on the Auto Place feature to select the most optimum layout for you. It will never work (unless it's an extremely simple board), regardless of what the program makers claim.

These tools do have one useful function however. They give you an easy way to get your components initially spread across your board.

Design for manufacturing

Panelisation:

If you are looking at getting your board automatically assembled with a pick-and-place machine, then it pays you to get as many boards onto the one "panel" as you can.

A panel is simply a large PC board containing many identical copies of your board. It takes time to place a board into position on a pick and place machine, so the more boards you can load at once, the more cost effective your manufacturing will be.

A panel will also contain tooling strips on the top and bottom, to allow for automated handling of the panel. Different manufacturers may have different maximum panel sizes they can produce.

Each individual board can be "routed out" and joined with "breakout tabs" or simply butted together and scoured out with a "V groove". A V groove is a score mark placed on your board that allows you to easily "snap" the board along the groove. A breakout tab is a small strip of board perhaps 5-10mm long joining your board to your panel. Small non-plated holes are also drilled along this strip which allows the board to be snapped or cut out of the panel after assembly.

You will need to consult your board loader to determine optimum panelisation size and requirements.

Tooling Strips:

Tooling strips are strips of blank board down the top and bottom side of your board. They contain tooling holes, fiducial marks and other manufacturing information if required.

Standard tooling holes are required for automated handling of your board. 2.4mm and 3.2mm are two standard hole sizes. Four tooling holes per panel is sufficient, one in each corner.

The tooling trips connect to your board(s) with breakout tabs or V Grooves.

Fiducial Marks:

Fiducial marks are visual alignment aids placed on your PC board. They are used by automated pick and place machines to align your board and find reference points. A video camera on the machine can identify the centre of fiducial marks and use these points as a reference.

On a panel there should be three fiducial marks, known as global fiducials. Bottom left/right and top left corners. They should be at least 5mm away from the board edges. They can be mounted on the tooling strips.

The fiducial mark should be a circular pad on the copper layer of diameter 1.5mm typically. The fiducial should not

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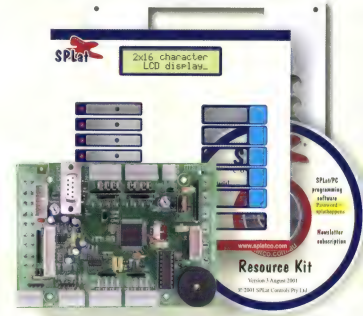

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be covered with solder mask and the mask should be removed for a clearance of at least 3mm around. The pad can be bare copper or coated like a regular pad.

Two local fiducial marks (in opposite corners) are also required next to each large fine-pitch surface mount device package on your board.

Thermal Relief:

If you solidly connect a surface mount pad to a large copper area, the copper area will act as a very effective heat sink. This will conduct heat away from your pad while soldering. This can encourage dry joints and other soldering related problems. In these situations a thermal relief connection, which comprises several (usually four) smaller tracks connecting the pad to the copper plane. Thermal relief options can be set automatically in many packages.

Soldering:

Soldering considerations need to be taken into account when laying out your board. There are three basic soldering techniques: hand, wave, and reflow.

Hand soldering is the traditional method typically used for prototypes and small production runs. Major impacts when laying out your board include suitable access for the iron and thermal relief for pads. Non-plated through double-sided boards should allow for ample room to get the soldering iron onto the top-side pads.

Wave soldering is a common process used for surface-mount and through-hole production soldering. It involves passing the entire board over a molten bath of solder. Solder masks are absolutely essential here to prevent bridging. The major thing to watch out for when designing is ensuring that small components are not in the wave solder "shadow" of larger components. The board travels through the wave solder machine in one direction, so there will be a lack of solder trailing behind larger components. Surface mount devices are fixed to the board with an adhesive before wave soldering.

Reflow soldering is the latest technique and is suitable for all surface mount components. The blank board is first coated with a mask of solder paste over the pads (solder "stencils" are used for this). Then each component is placed, and is sometimes held in place by an adhesive. The entire board is then loaded into an infrared or nitrogen oven and "baked". The solder paste melts (reflows) on the pads and component leads to make the joint. A newer reflow method called pin-in-paste or intrusive reflow is available for through-hole devices.

Combinations of wave and reflow soldering can be used for mixed through-hole and surface-mount boards. Wave soldering has the advantage of being cheap but the disadvantage of imposing placement limits on your components. Reflow soldering is more complex and expensive but it allows for very dense surface mount packing.

Basic PC board manufacture

A PC board usually consists of a blank fibreglass substrate ("the board"), which is usually 1.6mm thick. Other common thicknesses are 0.8mm and 2.4mm. There are many types of PC board substrate material but by far the most common is a standard woven epoxy glass material known as FR4. This material has standard known properties, typical values of which are shown in the accompanying table.

The most often-used parameter is probably the dielectric constant. This figure is important for calculating high-speed transmission line parameters and other effects. An FR4 PC board is made up of glass and resin. Glass has a dielectric constant of approximately 6, and the resin has a dielectric constant of approximately 3. So an FR4 PC board can typically have a figure ranging from under 4, to almost 5. If you need an exact figure you will have to consult with your PC board manufacturer.

Typical FR4 Properties

Dielectric Constant	3.9 to 4.8
Dielectric Breakdown	39kV/mm
Water Absorption	<1.3%
Dissipation Factor	0.022
Thermal Expansion	16-19ppm/°C

NOTE: These values can vary with manufacturers; check with your supplier for exact figures.

Other exotic base materials like Teflon are also available but are only used for special designs that require a higher grade base material for a specific reason.

There are cheaper materials than FR4, like phenolic base and CEM-1. These are hobbyist-grade boards but are also often used in some mass consumer products due to their low cost. They are not suitable for plated-through holes or fine tolerance designs.

A blank base material coated with copper is known as a copper clad board.

A multi-layer board is made up of various individual boards separated by Pre-impregnated Bonding Layers, also known as "prepreg". There are different ways to stack these board layers up and this will dictate what you can do with planes and blind/buried vias. Consult the manufacturer for their recommendations on this.

Surface finishes

You can get your PC board manufactured with several different types of pad and track surface finish.

Low cost single and double-sided boards without a solder mask typically have a roll solder finish on the copper tracks (commonly referred to as "tinned"). Beware of potential shorts between tracks with this method.

More expensive boards will typically have solder mask over bare copper (SMOBC) tracks and rolled solder (tinned) on the pads and vias which is Hot Air Leveled (HAL). Hot air leveling helps surface-mount components to sit flat on the board.

For large and critical surface mount components, a gold "flash" finish is used on the pads. This gives an extremely flat surface finish for dense fine pitch devices.

Peelable solder masks are available and are handy for temporary masking of areas on your board during wave soldering or conformal coating.

Electrical testing

You can have your finished PC board checked for electrical continuity and shorts at the time of manufacture. This is done with a automated "flying probe" or "bed of nails" test machine. It checks that the continuity of the tracks matches your PC board file. It may cost a fair bit extra but this is mandatory for multi-layer boards. If you have a manufacturing error on one of your inner layers, it can be very difficult to fix.

Signature

Like any work of art, no board is complete without adding your name or signature to it! The signature can take any form your like. Some people put

their name, initials or a fancy symbol. Whatever it is, just make sure you add something. A signature can be placed on any of the copper layers or on the component overlay.

Submitting your design for manufacture

The first thing to know is which format to send your PC board file in. In Australia the standard format is any version of Protel (AutoTrax, PFW2.8, 99SE, DXP etc). Every manufacturer in Australia will happily take a Protel file. In fact, Protel format is their preferred way to receive a file.

Many will also take other proprietary formats as well but you'll have to check with them first. Supplying the original PC board package file will ensure that what you see on the screen is what you will get when your board is delivered. Unless you have a good reason to do so, don't supply your file in any other format.

Gerber plot files are the traditional and industry recognised file format and all major manufacturers will accept them. Many PC board designers still insist on generating and supplying Gerber files themselves, in order to have total control over the manufacturing process. In all but a few cases, generating Gerber files is not necessary and a thing of he past. Generating Gerbers adds an extra step of complexity to the PC board process where errors can creep in. So avoid the use of Gerber files where possible; they can be troublesome unless you know exactly how to generate them correctly.

The manufacturer will ask for a lot of information before they quote. Ask them what you need to provide with your file. Here is a basic checklist:

- A reference code and revision for your board. This makes it easy for both parties to track the progress of it.
- Desired manufacturing time, known as the "turn-around". 24 hours will cost a LOT more than 2 weeks!
- Quantity of boards required
- Board thickness (1.6mm, 0.8mm, 2.4mm etc). 1.6mm is standard
- Type of board (FR4, Teflon etc). FR4 is standard
- Number of layers
- Surface finish (SMOBC, HAL, Gold Flash etc). SMOBC and HAL is standard.
- What colour you want your solder mask and component overlay.
- Copper weight (1oz, 2oz etc). 1oz is standard.
- Whether or not you want electrical testing.
- The Track/Space clearance of your board
- How your board dimensions are defined, eg, on the mechanical layer.
- Whether you want boards "panelised" or individually cut.

Many manufacturers will have "prototype" services where they fit as many of your boards onto a standard "panel" as they can, all for one fixed price.

In most cases you will be charged a "tooling" cost. This is the cost of printing the photo masks for your board and also setting up their machines. This is usually a one-off cost, so if you get the same board manufactured again, you won't have to pay the tooling charge.

Do you believe that is all there is to know about PC board design?

If you answered no, then you'd be right! Good PC board design takes lots of experience, so go get started on your next board using our tips.

Next month, we'll look at using the popular "Autotrax" and "Easytrax" PC board software. **SC**

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SPLat Controls microPLCs

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By PETER SMITH

SPLAT CONTROLS produce a range of Programmable Logic Controllers (PLCs) designed specifically for the OEM market. They boast very low start-up costs, simple expansion and easy programming. A custom design service is available, or you can build up your system from one of the standard off-the-shelf designs.

What's a PLC? PLCs provide the automation "engines" for industrial process monitoring and control. They've been around since the late 1960s, originally replacing complicated and unreliable banks of electro-mechanical relays. Today, PLCs are used in everything from industrial washing machines to full-blown discrete parts manufacturing lines.

TOP OF PAGE: As shown here, the MMi99 microPLC is also available as part of a sales demonstration kit. It's set up to simulate simple machine control, complete with LCD display, thermistor temperature sensor and appropriate front panel graphics. Companion software (supplied on CD) demonstrates the MMi99s serial communications capabilities.

Minis to micros

The earliest PLCs to use general-purpose computers for "back-end" processing were based on the DEC PDP-8 minicomputer. Not surprisingly, many times more computing power is now available in microprocessor-based systems at a tiny fraction of the cost.

All design-in (embedded) PLCs now use microcontrollers (or similar technology) for their processing elements. Microcontrollers integrate a microprocessor core with many of the peripherals needed in a typical PLC. To get a feel for the technology, let's have a look at one of SPLat Control's offerings, the MMi99 microPLC.

MMi99 microPLC

The MMi99 consists of a single PC board, measuring just 88 x 127mm. At the heart of the board is an 8-bit Motorola MC68HC908 microcontroller running SPLat's proprietary programming language.

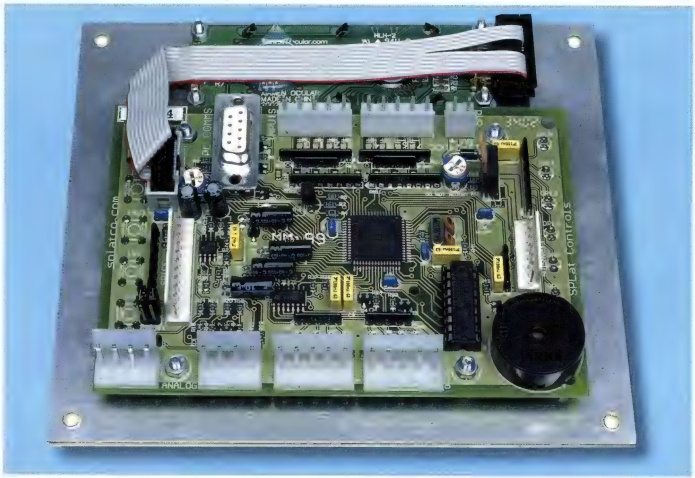
The board interfaces to the outside world via a series of I/O (input/output) ports, terminated on rows of push-on connectors. Included are two analog inputs, two analog outputs (both 8-bit), eight digital outputs (open collector) and eight digital inputs.

Both analog inputs can be configured to measure voltage, current or resistance, thus allowing direct temperature measurement using low-cost thermistors.

Five push-button switches and seven LEDs mount on the opposite side of the board, forming part of an in-built operator interface. This arrangement allows for direct mounting to an aluminium faceplate. A piezo "beeper" and connector for several popular liquid crystal display modules completes the interface.

A universal graphics overlay is available to suit the faceplate, making it possible to quickly assemble a "proof of concept" or one-off design.

On-board regulation means that the board can be powered from any 12 - 28V DC supply with around 200mA



A shot of the MMi99 mounted on the aluminium faceplate. The LCD module at the top is wired to the main board via ribbon cable. The input and output ports are terminated in rows of connectors along the top and bottom of the board. A D-9 connector is provided for RS232 (PC, modem, etc) communications. Connectors at the left and right sides are for expansion purposes.

capacity. Our review unit was supplied with a 12V DC 500mA plugpack.

Programming

As with all of SPLat's boards, the microcontroller on the MMi99 is programmed with a proprietary language designed specifically for PLCs. The high-level nature of this language means that it should be relatively easy to learn.

Controller programs are first written and simulated on a PC before being translated into a more compact form and uploaded to the FLASH memory in the MMi99's on-board micro. An RS232 port is provided on the board for the PC connection. This port can also be used for field updates, either via direct or modem connection.

The SPLat language contains a repertoire of over 200 instructions. For simple applications, however, you have the option of using a subset of the language called "Fast-track". With only 14 basic instructions to learn, PLC programming surely doesn't get any easier!

Expansion

For more demanding applications, the MMi99 can be expanded both in terms of I/O capability and functionality. Two on-board connectors are provided for this purpose.

The first of these is intended for connection to "SPice" add-on boards. The SPice interface provides a means of adding low-cost application-specific circuitry to the MMi99. For example, a typical SPice board might contain circuitry to condition the output of a sensor before it is fed into the MMi99 processor.

The second connector is designed for more sophisticated peripherals. SPLat Controls call this the "SPx" interface and it utilises an enhanced version of the industry-standard "SPI" serial bus for communication. An example of an off-the-shelf SPx board is the XIRO16, which adds eight digital inputs and eight relay outputs to the MMi99.

Going custom

The simple expansion system that SPLat Controls have incorporated in the MMi99 means that it shouldn't cost the earth to add capabilities to a basic system. Once a working system is proven, the results can be built as a complete custom controller, if quantities demand it.

And the good news is that your programming investment remains intact, thanks to the high degree of hardware abstraction that's part of this system.

More information

The MMi99 is available as a board on its own or as part of a developer's kit complete with front panel, LCD display, graphics overlay and software/documentation on CD-ROM.

Detailed information on SPLat Controls products can be obtained on-line at **www.splatco.com.au**. You can also reach them by phone on 03 9773 5082 or e-mail to **sales@splatco.com.au** SC

Check your DMM's accuracy with this:

MiniCal 5V Meter Calibration Standard

How accurate is your digital multimeter? Find out with this simple yet accurate DC voltage reference. If your meter fails the grade, the reference can be used as the calibration standard too. And as a bonus, we've thrown in a crystal-locked frequency reference which doubles as a crystal checker.

By BARRY HUBBLE

RECENTLY, THE NEED arose to recalibrate an expensive digital multimeter. As the job seemed quite straightforward, I decided to tackle it myself. Like most hobbyists, I don't have access to the high-accuracy voltage standards used in calibration labs. Nevertheless, I came up with a scheme that I thought would be accurate enough for general hobbyist work.

By hooking up five multimeters and two panel meters to a voltage divider across a battery, I figured that the mean reading should serve as a reasonable "standard". However, I was amazed to see that no two meters read the same and the range of values was much greater than I had anticipated.

Although the readings were probably within the specs for each meter, it was a sobering demonstration. In the absence of anything better, I calibrated my upmarket digital meter to the mean value but was determined to find a more accurate method that would give me some confidence.

The MiniCal solution

The Maxim range of IC voltage references proved ideal for this purpose. In particular, the MAX6350 +5V DC reference boasts a very impressive untrimmed accuracy of ±0.02%, with an extremely low temperature coefficient of 0.5ppm/°C.

Generally, voltmeters are calibrated on their lowest DC range (200mV for 3.5-digit meters). The "MiniCal", as this new project is called, divides down the MAX6350's +5V output to generate a 192.3mV reference.

In addition, the board includes a crystal-locked oscillator for checking meters, oscilloscopes and the like. The frequency of the oscillator is determined by crystal selection.

How it works

Fig.1 shows that the circuit consists of two completely separate sections.

With slide switch S1 in the lefthand

ABOVE: our Tektronix 4.5-digit meter is pretty much spot on, especially when the 0.02% accuracy of the MiniCal voltage reference is considered. Other (cheaper) meters might not be as accurate.

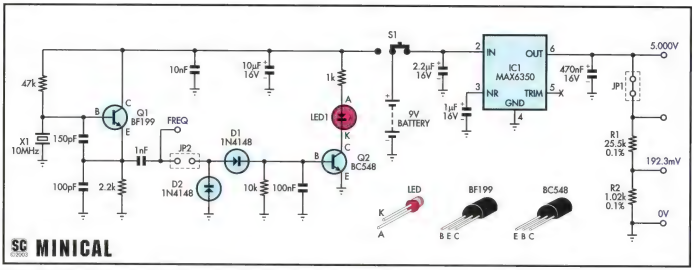


Fig.1: the MiniCal consists of independent oscillator and voltage reference circuits. To minimise noise on the voltage reference, only one of the circuits can be powered at a time, selectable via slide switch S1.

position, battery power is applied to the oscillator section. Some readers may recognise this circuit and, in fact, it's based on the "Simple Go/No Go Crystal Checker", originally published in the August 1994 edition of SILICON CHIP.

The basic Colpitts oscillator used in the original design proved ideal for the frequency reference section of the MiniCal. Although not strictly necessary, the circuit has been reproduced in its entirety, meaning that it can also be used as a crystal checker if so desired.

Crystal X1, the 150pF capacitor between Q1's base and emitter, and the 100pF capacitor to ground together form the feedback network. The output from Q1's emitter is AC-coupled via a 1nF capacitor to the "FREQ" test pin.

Although we've specified a 10MHz crystal for X1, the circuit should work with values from 1MHz to at least 21MHz without modification.

The remaining circuitry connected to Q1's emitter performs the crystal "go/no go" function. Diodes D1 & D2 and the 100nF capacitor rectify and filter the AC signal from the emitter. The resultant DC voltage is applied to the base of Q2, switching it on and lighting the "OK" LED whenever oscillation is present.

Voltage reference

With switch S1 in the righthand position, the voltage reference section of the circuit is powered. This section is very simple and consists of only a voltage reference IC, three capacitors and two resistors.

The MAX6350 (IC1) can operate with an input range of 8-36V, providing an untrimmed output of 5V ±0.02% (4.999V - 5.001V). Small tantalum capacitors on the input, output and "NR" (Noise Reduction) pins reduce circuit noise to just 3.0µVp/p (typical) in the 0.1Hz to 10Hz spectrum. Battery-powered operation ensures that this is not degraded by external (conducted) noise sources.

Note: the MAX6350 is available in both 8-pin DIP and SO (surface mount) packages. The PC board design accommodates both package styles. We expect that most constructors will opt for the surface mount device, as it is cheaper and easier to obtain (see parts list).

Resistors R1 & R2 divide down the MAX6350's +5V output to obtain the 192.3mV calibration voltage. At a minimum, these resistors need to be 0.1% types (see parts list) to achieve the specified 0.2% voltage tolerance.

As you can see, the use of 0.1% resistors degrades circuit performance somewhat. However, the result is a good compromise between accuracy and cost, and is sufficient for meter checking. If you want to use the MiniCal for calibration, then you will need to upgrade to tighter-tolerance resistors in order to meet the basic accuracy specs of your instrument.

Two alternatives for R1 & R2 are shown in the parts list. The 0.01% resistor pair gives a ±0.04% tolerance on the 192.3mV output but will set you back about $77. Alternatively, you can install the 0.05% 25:1 divider network for a tolerance of about 0.1% and a much lower cost of just $18.

Note: the 25:1 divider network consists of two 0.1% resistors (1kΩ & 25kΩ) with a ratio accuracy of 0.05%. The device is supplied in a 3-pin surface-mount (SOT-23) package.

So why did we choose an odd calibration voltage of 192.3mV instead of a nice round figure? Well, it was simply a convenient choice using available resistor values. Other division ratios could be used but for best results the reference voltage must be close to (but not exceeding) 200mV.

Main Features

- 5.000V ±0.02% voltage standard
- 192.3mV ±0.2% voltage standard (optional ±0.1% or ±0.04%)
- Two ±0.1% resistor standards (optional ±0.01%)
- Crystal-locked frequency reference
- Crystal checker

Construction

All parts mount on a single PC board coded 04112031 – see Fig.2. If you have surface-mount devices for IC1 and/or R1 & R2, these should be installed first (see Fig.3). You'll need a temperature-controlled soldering iron with a fine chisel tip and small-gauge solder for the job. A bright light, magnifying glass and 0.76mm desoldering

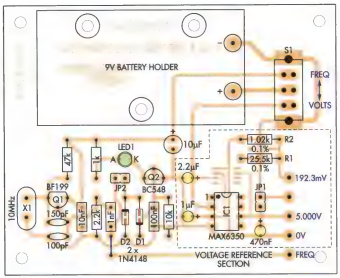


Fig.2: follow this diagram closely when assembling the board. Take care with the orientation of the diodes (D1 & D2) and tantalum capacitors. Note: this final version of the PC board differs slightly from the early version shown in the photographs

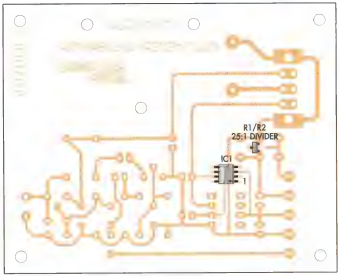


Fig.3: the PC board design can accommodate both conventional (DIP-8) and surface-mount (SO-8) package types for IC1. If you have the SO-8 type, then mount it on the copper side of the board as shown here. The optional 25:1 resistor network (R1/R2) also goes on this side.

braid ("Soder-Wick" size #00) will also prove useful.

Next, on the top side of the board (see Fig.2), install all components in order of height, starting with the wire link, resistors and diodes (D1 & D2). Obviously, if you've mounted the R1/R2 divider on the bottom side, then you shouldn't install anything in the R1 & R2 positions on this side!

Note that all the tantalum capacitors are polarised devices and must be inserted with their positive leads aligned with the "+" symbol marked on the overlay.

Install the battery holder last of all. It should be fixed to the PC board with No.4 x 6mm self-tapping screws before soldering.

To complete the job, attach small stick-on rubber feet to the underside of the PC board to protect the assembly as well as your desktop.

Operation

Due to the expected intermittent use of the MiniCal, a power switch has not been included. Simply plug in a battery and use the slide switch to select between the oscillator function ("FREQ") or voltage reference function ("VOLTS"). Note that the battery voltage must be at least 8V for correct operation of the reference IC.

When measuring the oscillator frequency, the crystal checker function must be disabled by removing the jumper from JP2. This is necessary because the checker circuit loads the

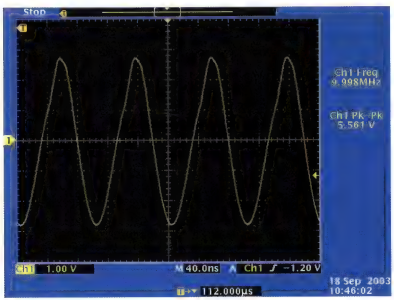
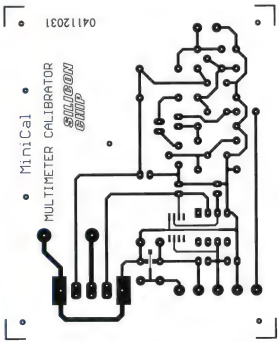
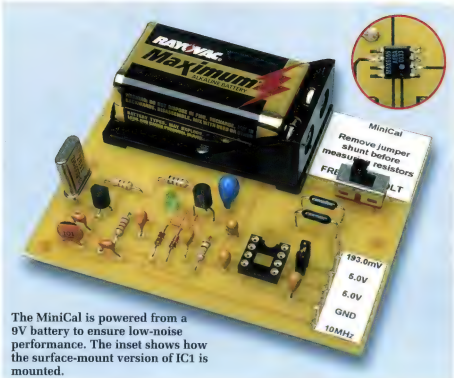


Fig.4: this oscilloscope shot shows the signal on the "FREQ" test pin with a 10MHz crystal installed. Fig.5 (right) shows the full-size etching pattern for the PC board.





The MiniCal is powered from a 9V battery to ensure low-noise performance. The inset shows how the surface-mount version of IC1 is mounted.

oscillator, reducing the signal on the "FREQ" test pin below the sensitivity level of most multimeters.

Follow the instructions provided with your multimeter regarding calibration. In general, most multimeters should be calibrated on their lowest (basic) range, which is normally 200mV for 3.5 digit models.

As described earlier, accuracy will be about ±0.2% using ±0.1% resistors for R1 & R2. This figure is good enough for many general-purpose instruments, which typically specify an accuracy of ±0.25% at best. Note that calibration instructions usually specify a standard of ±0.1% or better.

Calibration is normally only applicable to the basic range, with all other ranges depending on that calibration. The 5V output and 0.1% resistors should therefore only be used to check the accuracy of your meter, not to calibrate it. Note that, in use, the jumper shunt (on JP1) must be removed before measuring the 0.1% resistor values.

Note also that some meters may require special tools and/or knowledge for successful calibration. When in doubt, read the (service) manual first!

Meter loading effects

A resistive divider was chosen to generate the millivolt source because it's simple and requires no adjustment. However, the down side to this simplicity is that the meter's input impedance loads the divider network and therefore reduces the reference accuracy.

For example, when a meter with a 10MΩ input impedance is connected, the reference voltage will fall by about 0.02mV. This corresponds to a 0.01% reduction in accuracy. Assuming you know your meter's input impedance, the loading effect can easily be factored into the calibration where maximum accuracy is required.

Table 1: Capacitor Codes

Value	µF Code	EIA Code	IEC Code
470nF	0.47µF	474	470n
100nF	0.1µF	104	100n
10nF	.01µF	103	10n
1nF	.001µF	102	1n
150pF	–	151	150p
100pF	–	101	100p

Further reading

Detailed technical information on the MAX6350 voltage reference IC can be downloaded from the Maxim web site at **www.maxim-ic.com** SC

Parts List

1 PC board, code 04112031, 71mm x 88mm
1 10MHz crystal (X1) (user select, see text)
1 3mm green LED (LED1)
5 PC board pins (stakes)
2 2-way 2.54mm SIL headers (JP1, JP2)
2 jumper shunts
1 miniature DPDT PC-mount slide switch (Altronics S-2060, Jaycar SS-0823)
1 9V PC-mount battery holder (Altronics S-5048, Jaycar PH-9235)
3 No.4 x 6mm self-tapping screws
4 small stick-on rubber feet
1 9V battery

Semiconductors
1 MAX6350CPA (DIP) or MAX-6350CSA (SMD) voltage reference (IC1) (Farnell 162-097, also available from **www.futurlec.com**)
1 BF199 NPN RF transistor (Q1)
1 BC548 NPN transistor (Q2)
2 1N4148 diodes (D1, D2)

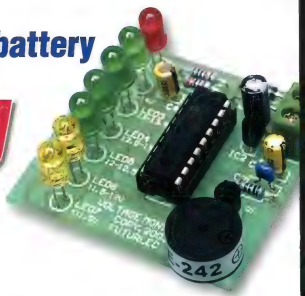
Capacitors
1 10µF 16V tantalum
1 2.2µF 16V tantalum
1 1µF 16V tantalum
1 470nF 16V tantalum
1 100nF 63V MKT polyester
1 10nF 63V MKT polyester
1 1nF 63V MKT polyester
1 150pF ceramic disc
1 100pF ceramic disc

Resistors (0.25W, 1%)
1 47kΩ 1 2.2kΩ
1 10kΩ 1 1kΩ
1 25.5kΩ 0.1% (R1) (Farnell 340-522)
1 1.02kΩ 0.1% (R2) (Farnell 339-180)
-OR-
1 25:1 0.05% resistor network, Vishay MPM series (Farnell 309-8576)
-OR-
1 25kΩ 0.01%, Vishay S102J series (Farnell 309-8175)
1 1kΩ 0.01%, Vishay S102J series (Farnell 309-8114)

Note: items listed with Farnell catalog numbers can be ordered direct from Farnell, phone 1300 361 005 or visit www.farnell.com

Don't get caught with a flat battery

Car Battery Monitor



This little Car Battery Monitor provides an early warning of battery problems. It has seven LEDs to indicate the battery voltage and a piezo buzzer to warn when the voltage drops below 12V.

By ALAN BONNARD

A CLOSE CALL on the road can really focus your mind on the importance of having a battery monitor in a car. I had been enjoying a pleasant week of travelling around the countryside at a leisurely pace and taking in the beautiful scenery each day. It wasn't until the final day, with the big rush to return home, that I had to drive at night.

My home is deep in the country and on the road I was travelling the closest petrol station may be 80km away. I was travelling through an area that is full of open-cut coal mines and large heavily loaded semi-trailers constantly pound the roads, travelling at quite high speeds. It was around 8pm at night and everything was very dark – no street lights or house lights anywhere.

Just as I was going up a hill, the lights began to dim and the engine coughed. A large semi-trailer loomed in the rear-vision mirror as I pushed the clutch in and tried to restart. My speed was falling rapidly and my lights were blacked out – I was like a sitting duck in the middle of the road, as the semi-trailer came rapidly bearing down on me.

I just managed to pull the car off the road, as the semi-trailer came screaming past, missing me by inches!

After calling for assistance from the NRMA, the problem was found to be a fault in the alternator, which was failing to charge the battery. The battery voltage had been falling under the heavy load of the lights and at the worst possible time, there was not sufficient power for the lights or the motor.

After the initial shock wore off, I put on my thinking cap to come up with a PIC-based solution to the problem. What was really needed was a display and a buzzer, to get my attention should the voltage fall outside a specified range. So my design criteria was set, a series of LEDs could indicate the voltage and a buzzer would also be used to warn of problems.

Where To Buy The Kit

This project is copyright to Futurlec. It is priced at $12.90 plus $4 for postage and packing. It can only be purchased from: **www.futurlec.com**

Circuit details

The circuit is based on PIC16F819 18-pin microcontroller which has an analog-to-digital (A/D) input to monitor the battery voltage and outputs capable of driving LEDs directly, to keep the component count down.

There are seven LEDs in all, giving a good range of voltage indication. The topmost LED, LED1, comes on for voltages above 14V which will occur when the battery is fully charged. LED2 indicates for voltages between 13.5V and 14V while LED3 indicates between 13V and 13.5V. Normally, one of these LEDs will be on. LED4 covers 12.5V to 13V while LED5 covers 12V to 12.5V.

LED6 covers from 11.5V to 12V while LED7 comes on for voltages below 11.5V. These two LEDs are backed up by the piezo chime which beeps for voltages between 11.5V and 12V and becomes more insistent for voltages below 11.5V.

That might seem fairly conservative. After all, most cars will start with no troubles, even though the battery voltage might be a touch below 12V, won't they? Well, no. Some modern cars will happily crank the motor at voltages below 11V but their engine management will not let the motor start unless the voltage is above 11V.

So don't think that a modern car will always start reliably. This little battery monitor could easily prevent a very inconvenient failure to start!

So let's describe the rest of the circuit. The incoming supply is connected via diode D1 which provides protection against reverse polarity while zener diode ZD1 provides protection from spike voltages.

A standard 7805 3-terminal regulator is then used to provide a stable 5V to the microcontroller. The battery voltage is sensed via a voltage divider using 33kΩ and 100kΩ resistors. This brings the voltage down to within the

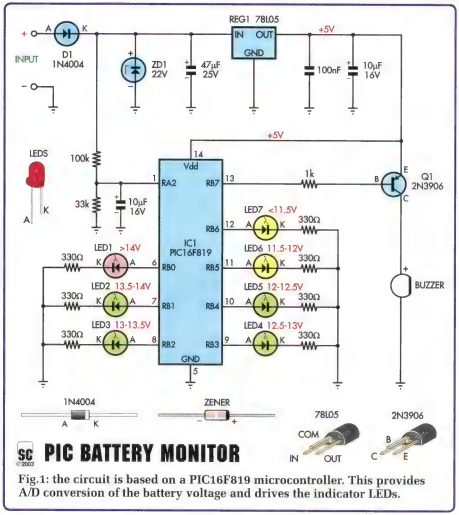


Fig.1: the circuit is based on a PIC16F819 microcontroller. This provides A/D conversion of the battery voltage and drives the indicator LEDs.

0-5V range for the A/D input of the PIC16F819. Port B (RB0 to RB7) of the microcontroller is then used to drive the various LEDs, with current limiting provided via the 330Ω resistor network. RB7, pin 13, drives a switching transistor for the piezo buzzer.

Software

For the software, the design follows the basic template for a PIC microcontroller. Port A and its ADC (analog-to-digital converter) function are set up while port B functions as the output for the LEDs and buzzer. Once the set-up is complete, a reading will be taken at port RA2, the input for the A/D convertor. This reading is then compared with a series of values to determine the range of the voltage. This is similar to a series of "if" statements in Basic language.

If the voltage is found to be within a certain range, the relevant port B pin will be turned on. If the voltage is below 12V, the buzzer will be turned on for a brief period, to signal a low battery condition. As the voltage falls below 11.5V, the frequency of the beeps will increase, to signal increased urgency.

Building it

All the parts are mounted on a small PC board measuring 46 x 46mm (available from Futurlec). The starting point should be the IC socket for the PIC16F819, as this is easiest to mount

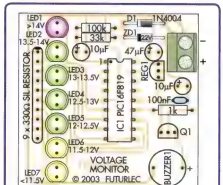


Fig.2: here's how to install the parts on the small PC board.

Main Features

- Visual indication of battery voltage
- Audible warning when voltage becomes low
- Screw terminals for easy connection
- Simple and easy to build

while the board is bare. The next item can be the PC terminal block. The resistors and capacitors can then follow. Make sure the electrolytics are inserted with correct polarity.

Make sure that you do not confuse the zener (ZD1) with the diode when you are installing them; the diode is the larger package of the two.

Even more important, don't get the 78L05 3-terminal regulator and the 2N3906 transistor mixed up; they come in identical packages. The 78L05 will be labelled as such while the 2N3906 will be labelled "3906". And make sure you insert them the correct way around.

The buzzer must also be installed with the correct polarity. The 330Ω current limiting resistors are all in a 10-pin in-line package.

There are four green LEDs, two yellow and one red. They need to be installed in line and with the correct orientation.

Testing

Before you insert the PIC16F819 microcontroller, do a voltage check. Connect a 12V source and check for the presence of 5V between pins 14 & 5 OF IC1. If 5V is not present, check the polarity of regulator REG1 and the polarity of the diode D1.

If these tests are OK, insert the IC and test the unit over a range of voltage between 9V and 15V. Make sure that all LEDs come on in sequence and the piezo buzzer beeps for voltages below 12V.

Now it is matter of installing the unit in your car. It is preferable to install the unit in a visible position for the driver. However, it should not obscure any other instruments. The unit should be connected to the car's 12V supply after the ignition switch. This will turn the unit off with the other instruments and prevent battery drain while the motor is not running. SC

A NEW "CLASS" OF PICAXE

Keyboards 101

by Stan Swan

New PC on the Christmas wish list? Kids getting your old PC (again)? Maybe they've already got your previous cast offs!? Can't bear to just throw out that new millenium keyboard you lovingly crafted prose and caressed spreadsheets with? Consider our PICAXE-18 (A or X) "PS/2 to RS-232" converter that creates a versatile 2-wire serial data sender, suitable linking to a remote terminal or LCD display.

With flair, the entire circuit and 3xAA battery power supply may even be able to be housed inside the keyboard – suiting perhaps a serial "computerless" keyboard able to send data for many kilometres along a simple two-wire link (refer "Damp String" Datacomms, July 2003 SILICON CHIP).

In spite of its recent multimedia and Internet variations, the PC's humble QWERTY keyboard surely is the industry's bargain workhorse, with a service life extending often well beyond its companion PC.

It is debatable in a commercial sense if it's worth cleaning spills and dirty finger marks off them, since in spite of their electronic and mechanical sophistication, new (barebones) keyboards sell for under twenty dollars – often well under.

But if you're prepared to spend a few minutes wash & brush up time, you'll no doubt be able to lay your hands on plenty of working ones (maybe even more after office Christmas parties!).

For this project however it's suggested you stick with relatively recent PS/2 models, since the original 1980s XT design is **not** PICAXE-18A/X friendly. In addition, even early 1990s AT types, especially those with the larger 5-pin DIN socket, may be power hungry.

Tests on assorted six-pin miniDIN PS/2 keyboards showed most were delightfully tolerant of lower supply voltages but some drew up to 70mA. Since the aim is to run the entire setup off the usual PICAXE 3xAA (4.5V) supply, it's best to use such a battery busting keyboard just for initial testing and keep your eyes peeled for one of the "smell of an oily rag" ones.

If you don't have a DMM to check working current, then open up the keyboard itself (mind the cockroaches!) and check the dates on the keyboard's inbuilt control electronic ICs.

We found an early 90s era HP had "9315" (= 1993 15th week) on its 40-pin Motorola controller and predictably drew a greedy 60mA even at 3V. The Y2K-era discard settled on finally drew just 2mA at voltages anywhere from 3 - 5.5V (thus matching a PICAXE needs well) and seemed typical of many such now available. Some PDA thin and "rollup" keyboards look even more frugal.

Use of such interfacing keyboards has been a popular PIC16F834 or Atmel AVR micro controller project for some years but coding has been a challenge to say the least!

PC keyboards operate via weird hex "scan codes" that follow no logical layout and are easiest dealt with via a lookup table.

Thankfully both the 18A and X PICAXES offer a convenient key-press **keyin** reading (which detects the key press at inputs 6 and 7) for **keyvalue** to lookup the associated "scan code" which can be neatly grouped for reading under the Picaxe **EEPROM** command.

These codes are seamlessly converted to ASCII, then further sent out as 2400bps serial RS232 data for terminal or LCD display (refer July and August 2003 SILICON CHIP articles).

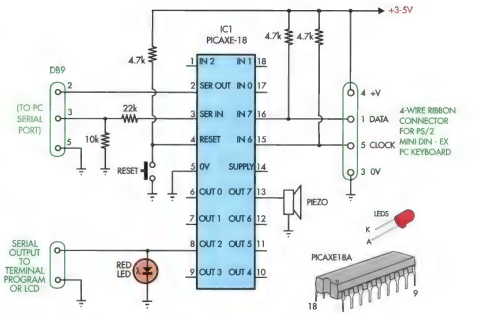
Given the 256-byte non-volatile RAM of both the 18A and X, it proved feasible to use half of this (bytes 0-127 are of course used by the EEPROM) as a keystroke memory buffer – these are displayed (and then overwritten) at next switch on.

This buffer could instead be used to send a prepared message(s) when certain keys were pushed, and feasibly could again hold temperature values from our November DS1B20 data logger as well.

Classic ASCII codes (pronounced "ass-key" = American Standard Code for Information Interchange) began use with the IBM PC in 1981 (but date in fact from 1963!), and represent one of the few forty-years-old computer technologies still thriving.

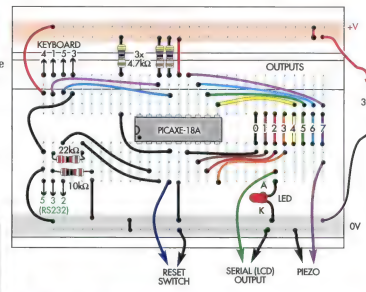
The first 128 numbers (256 = 2^8 for extended ASCII) are grouped into 31 non printing functions, such as 8 = BackSpace (BS) and 13 = Carriage Return (CR), while 32 – 128 represent normal alphanumeric characters (65= A, 66 = B etc).

Only CAPITALS are used in this program incidentally (these should be sufficient for messages such as

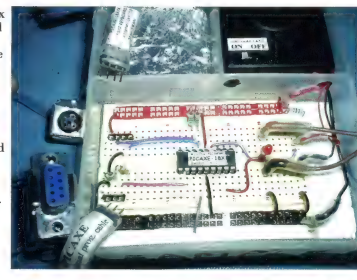


PICAXE-18A - "KEYBOARDS 101"

Circuit and protoboard layout, using the same overall scheme as last month. Pinouts for the keyboard socket (corresponding to the "keyboard" output numbers at right) are shown below.



This PICNIK box and proto-board layout is a bit simpler than the layout diagram above because we've removed all of the non-essential wires and links. The two pins painted white on the mini-DIN (keyboard) socket have no connection.



KEYB18XA.BAS

(Also downloadable from: www.picaxe.orcon.net.nz/keyb18xa.bas)

```
'KEYB1XA.BAS - for Dec 03 "Silicon Chip" PICAXE-18X/A article.Ver 1.02  2/11/03
'Converts attached PS/2 PC computer keyboard codes for ASCII display.NB-NOT the
'normal Prog.Editor PC kbd but an "old PC" one - selected for low power demands.
'EEPROM command preloads ASCII values into 18X/A data memory for lookup table.
'When key pressed,it's "value" used as the data memory address via the read cmd.
'The correct ASCII value is then shifted from the data memory into variable b1
'For PICAXE-18X/A or 28X only - will NOT work PICAXE-08 (since no "key" cmds).
'Refer article & schematic for kbd V & I findings + 18X/A connection details.
'Via Stan.SWAN =>s.t.swan@massey.ac.nz. Comment lines (starting ')can be ignored.
'-----------------------------------------------------------------------------
'       INPUTS        3-5V +supply   OUTPUTS                    PS/2   (5)(3)(1)(4)
'+ + + + + + + + + + + + + + + + + + + + +      keyboard    G   S
'|  ,-------------      |                        -typically  C  R     U
'o o o o------  |     |     SEROUT      _Piezo   a recent   L  O  D  P
'KBd.|      | |  ---------     |     |     one takes   O  U  A  P
'    |  0 1 2 6 7 =| PICAXE  |=0 1 2 3 4 5 6 7        just 2mA    C  N  T  L
'    |       =| 18X(A) |=     L                          @ 3V-5V !   K  D  A  Y
'    |_0V          ----------     E                      ==========
'       (SERTXD)   |* |          D          ** =wire to 4.7k   | | | |
' |||----------------/ * |    | | | | | | | | | pullup R & reset   | | | |
'Prog.    - - - - - - - - - - - - - - - - - -          Ch  0V Ch +5V
'input  Common gnd for serial,kbd,piezo & supply     PICAXE-18X/A => 6     7
'-----------------------------------------------------------------------------
serout 2,n2400,(12,"PC keyboard + PICAXE-18X/A terminal") 'Power switch on title
wait 1: serout 2,n2400,(12) '1 sec.title display then FF(12=FormFeed) = new page
for b0=128 to 255           'sweep thru' all upper 128 non volatile RAM locations
read b0,b1                  'stored data values readout to terminal/ LCD at switch on
serout 2,n2400,(b1)         'EEPROM occupies first 128 bytes of course,so just 128 ch.
next b0                     '~20 spaced words,buffer stored for next power on display
serout 2,n2400,(32)         'space indictes end of buffered text & fresh display start
'-----------------------------------------------------------------------------
reset: b0=127               'reset for RAM storage -first 128(0-127) used EEPROM "keyvalues"
kbd:                        'decoding/display routine. SERTXD cmd ideal initial 18X tweaking
for b0=128 to 255           'increment for last 128 keystrokes capture.NB-overwrites earlier
keyin                       'Get the keyboard press.NB-all processing stops until received!
read keyvalue,b1            'convert key value from keyin cmd into an ASCII character as b1
if keyvalue=$5A then crlf   'Carriage Return & Line feed routine for Enter key ($5A)
if keyvalue=$66 then bksp   'backspace key routine for BkSp key ($66)

'sertxd (b1)    'display @4800bps ASCII ch.(via inbuilt F8 ?)NB:SERTXD 18X only!
'pulsout 2,500   'LED flash output 2 confirms key push. SEROUT flashes LED also

serout 2,n2400,(b1)         'pin 2 2400 bps serial output for terminal/LCD display. 18A/X
sound 7,(100,5)             'key push sound- alter to suit (usual syntax).Remove if tedious !
pause 100                   'may be needed to prevent double ch. sending-alter to suit ~150 ?
write b0,b1                 'stores last 128 raw keystrokes (less CRLF & BS) non volatile RAM
if b0=255 then reset        ' allow for overwriting initial stored keystroke buffer
next b0                     'increment RAM storage location until 128 ch. buffer is full
goto kbd                    'NB:18X SERTXD ideal tweaking- maybe 'rem out finally (as here)?
'-----------------------------------------------------------------------------
crlf:                       'CR & LF routine to action 'Enter' key press.(ASCII values)
serout 2,n2400,(13,10)      'force a CR(=13) & LF(=10) for new line display on terminal
sound 7,(80,20)             'old typewriter CR sound (!?)-alerts to different key press
pause 200                   '"typomatic" delay to prevent double action- alter to suit
goto kbd                    'loop back to main key decoding routine
'-----------------------------------------------------------------------------
bksp:                       'BackSpace routine to action 'BkSp' keypress.(ASCII values)
serout 2,n2400,(8)          'force a BS(=8)on terminal.NB Some term. progs.may 'ignore'
sound 7,(50,20)             'raspberry sound (!?)- alerts to different key press
pause 10                    'short delay prevents double BS keypress- alter to suit
goto kbd                    'loop back to main key decoding routine
'-----------------------------------------------------------------------------
'Keyvalue data via Picaxe Editor:->file ->open ->samples ->keyin.bas CAPITALS only!

EEPROM $00,("?975312C?A864?'?")     'FN KEYS-all EEPROM values are hexadecimal(base 16)
EEPROM $10,("???7Q1???ZSAWZ?")      'MAIN KBD.Keyvalues run $10-$1F. So $1C=A,$1D=W etc
EEPROM $20,("?CXDE43??`VFTR5?")     'NB "gap" before the "V" =SPACE BAR (keyvalue $29)
EEPROM $30,("?NBHGY6???MUJ78?")     'Refer keyvalue list =>Help- Picaxe-18 -Basic cmds
EEPROM $40,("?,KIO09?./L;P-?")      'Use "If keyvalue =$xx then action" for 'capture'
EEPROM $50,("??'?[=?????]????")     'further specific keys.Thus if keyvalue=$76 (= Esc)
EEPROM $60,("??????????1?47???")    'force term.'Escape' action -> serout 2,n2400,(12)
EEPROM $70,("0.2568??B+3-*9??")     'NUMERIC KEYPAD.where 12=FF (ASCII) to clear screen
```

TABLE 8 – SORRY - YOUR TURKEY IS BURNT) but with the huge (600 code lines) memory of the 18X, code can be extended to action further keys as required.

The circuit has again been built onto breadboard PICNIK-18 style (refer November SILICON CHIP), for clarity stripped to just those few wires actually needed.

Old PC motherboards should supply a (de soldered) PS/2 socket, so that a convenient four-wire ribbon cable – PCB header pin adaptor can be used.

If you are sacrificing the keyboard however, just cut its fiddly PS/2 plug off to access and strengthen (perhaps with IC socket leads) these four wires for direct connection.

Don't forget the two 4.7k pullup resistors to Picaxe inputs 6 and 7, and also a similar 4.7k at the "18" reset pin (4).

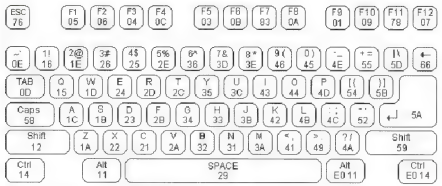
A reset push switch (to ground) may be useful here, if only to ensure just the Picaxe is reset and thus give cleaner output than a power off (which also switches the keyboard).

Remote display (for output 2) can be via any terminal program, such as Hyperterminal, Bananacom or even the convenient Picaxe editor's "F8". The Rev. Ed. AXE033 serial LCD,

References and parts suppliers

(also refer to previous months articles)

1. www.asciitable.com lists a lucid (extended) ASCII table.
2. www.beyondlogic.org/keyboard/keybrd.htm covers classic AT keyboard interfacing
3. www.picaxe.co.uk (Revolution Education) – generously provided 18X & A insights and graphics.
4. www.picaxe.com.au (MicroZed) – Australian master distributor for all Picaxes and accessories
5. www.picaxe.orcon.net.nz Authors Picaxe resource site with program listings and numerous links.



Scan codes for a standard keyboard. Using the code opposite, the PICAXE will decode these for further use.

although only a 16 x 2 display (and needing a good 5V supply), works well too and naturally removes the need for a display computer.

Don't neglect old but reliable DOS notebooks and mono organisers (perhaps with damaged keyboards!) – most have terminal ability too and some (such as the Sharp OZ/ZQ Wizards or Casio PV organisers) draw only tiny currents. The "18X" can valuably have its baud rate wound up from 2400bps to suit these.

Although the program runs on either the 18A or 18X, the latter controller offers a handy SERTXD "tweaking" feature over its programming cable, much as does the baby "08"via serout 0 .

It's actioned on an 18X by pushing F8, and directs serial output data (suitably SERTXD instructed) back to the editing PC (at 4800 bps as well). Naturally this saves the inconvenience of both program and D9 cable swapping if you've only a single PC.

It's tempting to feed the serial data to a low power 433.92MHz LIPD transmitter (such as the cheap TWS/RWS pair) for wireless use, with a perhaps a decoding "08" at the far end.

Tests with these devices, with ranges enhanced by a 4 element Yagi gave useful signals at several km (see www.picaxe.orcon.net.nz/yagi433.jpg). We might have a more detailed look at these sometime in the future, depending on interest.

But, as confirmed in both my "08" articles and the November Silicon Chip "Mr. Vineyard" modem, slower data rates (300 bps?) and "massaging" seem inevitable, since useful may not mean reliable... We'll cover simple wireless workarounds, using interrupts and infrared, as part of our next article early next year.

Happy QWERTYmas ! **SC**

NEXT MONTH:

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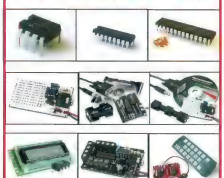

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VINTAGE RADIO

By RODNEY CHAMPNESS, VK3UG

The AWA PF 11B-6V car radio and the Ferris "Tranimate"

We often think that transistorised radios are a fairly recent innovation. However, solid-state equipment has been around in reasonable quantities since the late 1950s or almost half a century! As a result, many transistorised receivers now fall into the "vintage" category.

The two items described in this article certainly fall into that category. For example, the AWA PF 11B-6V car radio was a mid-1960s all-transistor receiver, that was available in two models: a "standard" model with a single-ended audio output and an up-market unit with a push-pull audio output stage.

The other unit to be described is the Ferris "Tranimate" which, to the best of my knowledge, was a unique Australian innovation. In the 1960s, dedicated car radios were expensive "add ons" and this little device was intended to allow an ordinary household transistor portable to function as a cheap but effective car radio. A car radio antenna was installed on the car, with its coaxial lead plugged into the Tranimate. The output from the Tranimate was then coupled to the portable radio and bingo – you had a cheap car radio.

AWA VW-1200 car radio

There are lots of people involved in restoring old cars, often to "as-new" condition – and in many cases, better than new. And of course, they want the radio that's installed to look and work just as it did many years ago.

As a result, I've recently been involved in restoring several car radios for vintage car enthusiasts. The jobs are not always straightforward though, since car radios are usually a bit more of a challenge to restore than "bog-standard" 5-valve AC mantel radios. That's mainly because car radios are more compact and so are harder to access than domestic receivers. They have also invariably had a rougher life and are usually better performers than metal receivers, which means that you have to know how to get the most out of them.

Still, it's always interesting to restore these old radios and it helps me recoup some of the outlay for my hobby.

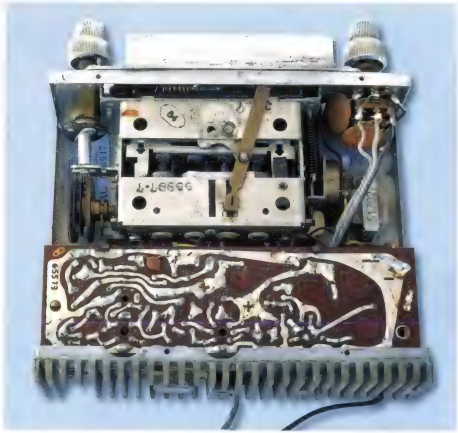
I'm not too sure how the Volkswagen driver found me – he simply turned up one day and asked me if I could get his 6V AWA car radio going properly. It was operating but only just – the stations that could be picked up were very weak and the set had quite a bit of noise in it.

Well, it looked like an interesting project and as luck would have it, I already had a circuit for the 12V version of the set (it's very similar to the 6V version). I don't like tackling a restoration job without a circuit diagram if at all possible, since the job is always so much quicker and easier if you have the circuit details.

This old AWA car radio receiver cleaned up quite well and will certainly look the part inside the restored Volkswagen. Note the press button tuning.

Opening up the receiver

The first step was to remove the cover (shield) from the set and this is



The PC board is mounted upside down inside the chassis but is quite easy to detach and "swivel" away from the finned heatsink. Note the large preset tuning mechanism.

done by removing 12 screws around the top of the case and lifting it clear (car radios are shielded to minimise external interference). This reveals a sheet on the inside of this cover, showing the locations of the various transistors and the alignment points on the PC board. This sort of information is always very useful when it comes to servicing the set.

As shown in the above photo, the PC board is mounted upside down inside the case with its track side facing upwards. In order to gain access to the component side, it is necessary to first "spring" a couple of clips along the front edge of the PC board. That done, the front edge of the board can be lifted up and moved forwards slightly. This disengages the board from slots in the heatsink and its back edge can then be swivelled up.

Once it's out, it would be quite easy to short parts of the board to the earthed metal clips that hold the board in place. As a result, I placed a layer of thick cloth between the board and the clips to prevent this from happening. I than took a look at the various stages inside the set but could see nothing that was obviously wrong – ie, no broken wires, overheated components or the like.

Audio stage troubleshooting

My next step was to connect the receiver to a 6V DC regulated supply capable of delivering up to 3A.This coped quite easily, as the receiver's drain is just 1.2A maximum. I then connected an antenna to the set and plugged in a 16-ohm loudspeaker.

When it was turned on, it behaved just as it did in the car. The reception was so noisy receiver that it was a struggle to pick out any of the stations. However, this noise was still there when the volume control was turned down, so that part of the problem certainly didn't involve the RF section.

Next, I installed a 1000µF electrolytic capacitor across the base to emitter junction of the 2N408 transistor in the audio output amplifier and the noise disappeared. Because the audio amplifier is direct coupled, I reasoned, incorrectly as it turned out, that the 2N408 was noisy (this can be a problem with germanium transistors). I didn't have

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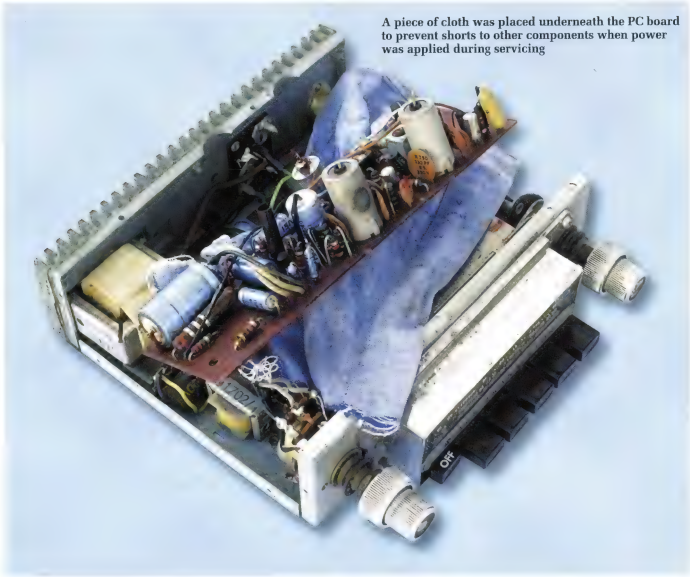

A piece of cloth was placed underneath the PC board to prevent shorts to other components when power was applied during servicing

any 2N408 germanium transistors, so I fitted a BC558 silicon transistor instead. The transistor worked OK but the noise was still there.

It was then that I spotted an electrolytic capacitor that was starting to bulge at one end. This too was replaced but rather surprisingly, it made no difference.

What next to try? First, resistor R20 needed to be replaced with a lower value, so that the BC558 I had substituted (and the other stages) would be biased correctly. The original resistor was 15kΩ (remember this is the 6V version of this receiver), so I replaced it with a 10kΩ resistor. And would you believe it? – the noise disappeared.

So I had jumped to the wrong conclusion that the old germanium transistor was noisy. In fact, I should have woken up to this when I first tried the electrolytic capacitor across the base-emitter junction. The audio stage now performed as it should, with quite good gain and just a slight background hiss, so I was half-way through fault finding.

RF stage repairs

Checking the front end wasn't quite as easy, not that direct-coupled audio stages are always a joy to work on. The set couldn't receive any stations, so I decided to begin by checking the intermediate frequency (IF) stage.

To do this, I first connected a 10nF ceramic capacitor in series with the output of an RF signal generator. The RF generator was then set to 455kHz and its output fed, in turn, to various points of the IF amplifier. However, the output levels varied according to where the probe was placed, due to the capacitive voltage divider and the heavy loading I was placing on the tuned circuits with the crude probe I was using. As a result, there was no clear-cut indication of the performance of the IF amplifier.

Next, I fed the RF generator's signal into the base of the converter (VT2) and carefully aligned the IF amplifier stages. This noticeably improved the performance of this stage but the receiver was still having trouble picking up stations.

By now, I was beginning to think that the converter wasn't converting the signal frequency to the IF (intermediate frequency). To test this theory, I tuned the set to the low-frequency end of the dial and then tuned another receiver to 1200kHz and placed its antenna lead adjacent to the car set's converter stage. I then tuned the car

radio upwards from 530kHz and was greeted by noise quietening as the car radio's oscillator went past 1200kHz.

So the oscillator was working and hence the converter probably was too. But there was still no sign of stations!

I then did some measurements around the RF stage and found that there was 6V on the collector of this transistor instead of 0V. The cause wasn't hard to find – RF choke L2 was open circuit! A quick hunt around my workshop soon turned up some small Dai-1Chi 5mH RF chokes that I had and I fitted one into the receiver. And that was it – the collector voltage on the RF transistor dropped to 0V and the set burst forth into glorious sound.

Now that the set was operating properly, all that remained was to align the front end and give it a good clean up. The oscillator alignment was already correct but trimmer capacitor C7, which peaks the RF stage at the high frequency end of the tuning range, had been adjusted for maximum capacitance and was difficult to move. In fact, it appeared that the trimmer didn't have enough range to peak the alignment of this stage. This problem was solved by connecting a 10pF NPO ceramic capacitor in parallel with the trimmer (under the board), after which I was able to peak the RF stage alignment.

Final peaking of the RF and oscillator stages is carried through a hole in the base of the set once the metal cover is back in place. In particular, the antenna circuit cannot be peaked until the receiver is in the vehicle and attached to the fully extended antenna. To do this, the set is tuned to a weak station at around 1500kHz and the flat knob on the underside of the set is rotated until the best performance is achieved.

Cleaning up

Having got the set working correctly, I then proceeded to clean up the case as much as practical. The knobs were washed in the laundry sink in soapy water and I used a small nail brush to remove the dirt from between the ridges in the knobs. In addition, the two smaller knobs had peeling black paint in their centres so I put a small amount of flat black enamel paint on them to make them look original.

The case itself had a couple of pieces of masking tape and other bits of muck stuck to it which I scraped off. I then used a eucalyptus-soaked rag to clean the case and the front panel. A kitchen scourer was then used to remove some of the more stubborn marks although this was done rather gently because I didn't want to destroy any of the wanted markings on the case.

In the end, both the case and the front panel looked quite good, although they still weren't exactly in pristine condition.

Photo Gallery: Peter Pan Model BKJ 5-Valve Receiver

Housed in a stylish wooden cabinet, the Peter Pan BKJ was a 5-valve dual-wave mantel receiver which covered the medium-wave (broadcast) and the 5.88-18.75MHz shortwave bands. It was manufactured around 1946 by Eclipse Radio Pty Ltd (Melbourne) and used the following valves: 6J8-G frequency changer; 6U7-G IF amplifier; 6B6-G detector, AVC detector and first audio amplifier; 6V6-G audio output; and 5Y3-G rectifier. (Photo courtesy Historical Radio Society Of Australia (Inc.).

Brief circuit details

OK, let's now take a brief look at the circuit details of this AWA car radio receiver – see Fig.1. As shown, the antenna input is a typical car radio input circuit, where the capacitance of the coaxial cable from the antenna forms part of the tuned circuit. That's why the antenna circuit cannot be peaked for best performance until the set is installed in the car. Note that the actual tuning of this and the following stages is done by a variable inductance tuner.

Transistor VT1 amplifies and applies the signal through another inductance tuned circuit to an autodyne mixer/converter stage based on transistor VT2. This stage converts the

A Note On IF Alignment

The December 2002, January 2003 and February 2003 issues covered the subject of receiver alignment. As a follow-up to this, John Breden from New Zealand advocates doing the IF alignment with the tuning gang in the fully unmeshed position, as this obviates the possibility of tuning the IF to the bottom of the broadcast band when the gang is closed.

This can and has happened when the IF alignment is done without using a signal generator.

It is rare but does happen when over-enthusiastic people alter the alignment adjustments without knowing what they are doing. Using a signal generator ensures that the IF is aligned to the correct frequency. So if you do align the IF without using a signal generator, just be careful you don't fall into this trap.

The Ferris "Tranimate"

Ferris Radio (Australia) were renowned for making many innovative devices and the "Tranimate" was one of them. "What's the Tranimate?", you may well ask. Well, the Tranimate was a 2-transistor tuned amplifier designed to accept a signal from a car radio antenna and output it to a domestic portable transistor radio.

It worked like this: a car radio antenna was installed on the car, complete with its coaxial cable lead. This lead was then plugged into the Tranimate which was screw-mounted to the underside of the dash panel of the car (remember, you could do those things in 1960s cars).

The Tranimate had an input tuned circuit and this was manually tuned by a small tuning gang. The dial was calibrated with some stations but being so small, only a few representative stations were marked.

The tuned signal was first amplified by a transistor operating in common emitter configuration and then fed to a second transistor wired as an emitter follower. From there, the resulting RF output was then fed down a thin coaxial cable to a ferrite-cored coil which was clipped to the transistor radio so that it was in line with the portable's loopstick antenna. As a result, the signal in the Tranimate's coil was induced into the loopstick antenna and so the portable received a clear signal.

Of course, a portable radio will work in a car without a "signal booster" such as the Tranimate. However, the signals tend to be weak and the vehicle's electrical equipment, particularly the ignition system, interferes severely with reception. Hence the reason for the Tranimate – it picked up a relatively noise-free signal in a good signal environment and amplified it so that the noise from the vehicle's ignition became insignificant.

The Tranimate was powered by a 216 battery slipped into the case at one end. The circuitry inside the plastic case is shielded from interference within the vehicle by metallic plating of the inside of the case. The tuning dial on the front is peaked up for best reception of the station being received.

The top view shows the Ferris "Tranimate", complete with its coupling coil and connecting coaxial cable, while immediately above is the view inside the case. The complete unit is around the size of a packet of cigarettes.

So that was it – a simple little device that filled a small niche market for the many people who could not afford both a transistor portable and a car radio at the time. I doubt that it proved to be a winner and I obtained mine at a clearance price. Still, it's a desirable item to have in a vintage radio collection, because they are so rare and innovative for their era.

input signal to 455kHz and feeds it to the IF stage.

The IF stage is based on VT3. It amplifies the signal and because of the high gain of this stage, it is neutralised using capacitor C18. AGC is developed from the signal at VT3's collector via C17 and diode MR1. This AGC is only applied to VT1 in the RF stage but, although it's only applied to this one stage, is still quite effective.

Detector

Diode MR2 at the output of IF transformer TR3 functions as the detector. It feeds the detected audio signal to the volume and tone controls, and thence to the audio amplifier stage which is based on transistors VT4-VT6. Direct-coupled audio amplifiers are quite common and in operation, each stage interacts with the others. This can make fault-finding difficult if there is a DC fault.

Because some of the transistors are germanium types, it is necessary to stabilise the audio amplifier against thermal runaway with increased temperature. This is done using thermistor TH1 which acts to stabilise the current drawn by the audio amplifier with increased temperature.

VT5 is the only NPN transistor and it has a small heatsink attached to it. VT6, a 2N301, is mounted on the rear heatsink and only gets slightly warm, even after the set has been running for some time. An auto transformer (L7) couples the audio signal on VT6's collector to the loudspeaker.

Summary

This AWA car radio is a good example of germanium transistor design. The circuit is relatively simple and by altering just a few components, the basic design can be adapted to either 6V or 12V DC operation. It is also quite a good performer for a car radio from the 1960s.

This particular set was not difficult to restore and it showed only moderate signs of wear and tear. The press-button station selector still works well and in general, it's a receiver I would be happy to have in my collection.

The only real criticism I have is that the PC boards of the era are hard to work on. The leads coming through the board are usually bent over along the copper tracks, making it difficult to remove a component for testing. It's also necessary to be careful when soldering to ensure that the tracks aren't heated excessively, otherwise they will separate from the board or damage one of the leads.

Finally, I find that the circuits on these phenolic boards are difficult to trace at times! And the draughtsman who drew the circuit diagram omitted the earth/chassis connection on the 0V rail. SC

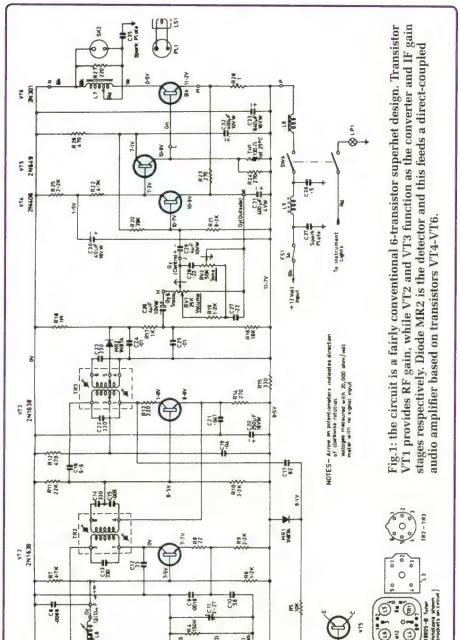

Fig.1: the circuit is a fairly conventional 6-transistor superhet design. Transistor VT1 provides RF gain, while VT2 and VT3 function as the converter and IF gain stages respectively. Diode MR2 is the detector and this feeds a direct-coupled audio amplifier based on transistors VT4-VT6.

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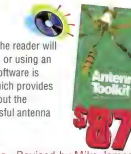

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April 1997: Simple Timer With No ICs; Digital Voltmeter For Cars; Loudspeaker Protector For Stereo Amplifiers; Model Train Controller; A Look At Signal Tracing, Pt.1; Battery Zapper Rejuvenates, Pt.8.

May 1997: Neon Tube Modulator For Light Systems; Traffic Lights For A Model Intersection; The Spacewriter – It Writes Messages In Thin Air; A Look At Signal Tracing; Pt.2; Cathode Ray Oscilloscopes, Pt.9.

June 1997: PC-Controlled Thermometer/Thermostat; TV Pattern Generator, Pt.1; Build A Stereo Microphone Preamplifier; Level Controller For 12V/24V Motors; Manual Control Circuit For Stepper Motors.

July 1997: Infrared Remote Volume Control; A Flexible Interface Card For PCs; Points Controller For Model Railways; Colour TV Pattern Generator, Pt.2; An Intro To Short Wave Radio Control Receivers.

August 1997: The Bass Barrel Subwoofer; 500 Watt Audio Power Amplifier Module; A TENs Unit For Pain Relief; Addressable PC Card For Stepper Motor Control; Remote Controlled Gates For Your Home.

October 1997: Build A 5-Digit Tachometer; Add Central Locking To Your Car; PC-Controlled 6-Channel Stereo/Surround Sound Audio Power Amplifier, Pt.3; Customising The Windows 95 Start Menu.

November 1997: Heavy Duty 10A 240VAC Motor Speed Controller; Easy-To-Use Cable & Wiring Tester; Build A Musical Doorbell; Replacing Foam Speaker Surrounds; Computer Controlled Dual Power, Pt.4.

December 1997: Speed Alarm For Cars; 2-Axis Robot With Gripper; Stepper Motor Driver With Onboard Buffer; Power Supply For Stepper Motor Cards; Understanding Electronic Lighting Pt.2; Index To Vol.10.

January 1998: Build Your Own 4-Channel Lightshow; Pt.1 (runs off 12VDC or 120VAC); Computer Control System For Model Railways, Pt.1; Pan Controller For CCD Cameras.

February 1998: Multi-Purpose Fast Battery Charger, Pt.1; Telephone Exchange Simulator For Testing; Computer Control System For Model Railways, Pt.2; Build Your Own 4-Channel Lightshow, Pt.2.

April 1998: Automatic Garage Door Opener, Pt.1; 40V 8A Adjustable Power Supply, Pt.1; PC-Controlled 0-30kHz Sinewave Generator; Build A Laser Light Show; Understanding Electronic Lighting, Pt.3.

May 1998: Troubleshooting Your PC, Pt.1; Build A 3-LED Logic Probe; Automatic Garage Door Opener, Pt.2; Command Control For Model Railways, Pt.4; 40V 8A Adjustable Power Supply, Pt.2.

June 1998: Troubleshooting Your PC, Pt.2; Universal High Energy Ignition System; The Roadies' Friend Cable Tester; Automatic Stepper Motor Controller; Command Control For Model Railways, Pt.5.

July 1998: Troubleshooting Your PC, Pt.3; 15W/Ch Class-A Audio Amplifier, Pt.1; Simple Charger For 6V & 12V SLA Batteries; Automatic Semiconductor Curve Tracer; Understanding Electronic Lighting, Pt.8.

August 1998: Troubleshooting Your PC, Pt.4; Simple I/O Card With Automatic Data Logging; Build A Beat Triggered Strobe; 15W/Ch Class-A Stereo Amplifier, Pt.2.

September 1998: Troubleshooting Your PC, Pt.5; A Blocked Air-Filter Alarm; Wax-Wax Pedal For Guitars; Logic Ladder; Gear Change Indicator For Cars; Capacity Indicator For Rechargeable Batteries.

October 1998: AC Millivoltmeter, Pt.1; PC-Controlled Stress-O-Meter; Versatile Electronic Guitar Limiter; 12V Trickle Charger For Float Conditions; Adding An External Battery Pack To Your Multimeter.

November 1998: The Christmas Star; A Turbo Timer For Cars; Build A Poker Machine, Pt.1; FM Transmitter For Musicians; Lab Quality AC Millivoltmeter, Pt.2; Improving AM Radio Reception, Pt.1.

December 1998: Engine Immobiliser Mk.2; Thermocouple Adaptor For DMMs; Regulated 12V DC Plugpack; Build A Poker Machine, Pt.2; Improving AM Radio Reception, Pt.2; Mixer Module For F38 Gliders.

January 1999: High-Voltage Megohm Tester; Getting Started With BASIC Stamp; LED Bargraph Voltmeter For Cars; Keypad Engine Immobiliser; Improving AM Radio Reception, Pt.3.

March 1999: Getting Started With Linux; Pt.1; Build A Digital Anemometer; Simple DIY PIC Programmer; Easy-To-Build Audio Compressor; Low Distortion Audio Signal Generator, Pt.2.

April 1999: Getting Started With Linux; Pt.2; High-Power Electric Fence Controller; Bass Cube Subwoofer; Programmable Thermostat/Thermometer; Build An Infrared Sentry; Rev Limiter For Cars.

May 1999: The Line Dancer Robot; An X-Y Table With Stepper Motor Control, Pt.1; Three Electric Fence Testers; Heart Of LEDs; Build A Carbon Monoxide Alarm; Getting Started With Linux; Pt.3.

June 1999: FM Radio Tuner Card For PCs; X-Y Table With Stepper Motor Control, Pt.2; Programmable Ignition Timing Module For Cars, Pt.1; Hard Disk Drive Upgrades Without Reinstalling Software?

July 1999: Build A Dog Silencer, 10µH to 19.99mH Inductance Meter; Build An Audio-Video Transmitter; Programmable Ignition Timing Module For Cars, Pt.2; XYZ Table With Stepper Motor Control, Pt.3.

August 1999: Remote Modem Controller; Daytime Running Lights For Cars; Build A PC Monitor Checker; Switching Temperature Controller; XYZ Table With Stepper Motor Control; Ignition Lighting, Pt.1.

September 1999: Autonomouse The Robot, Pt.1; Voice Direct Speech Recognition Module; Digital Electrolytic Capacitance Meter; XYZ Table With Stepper Motor Control, Pt.5; Petrier-Powered Can Cooler.

October 1999: Build The Railpower Model Train Controller, Pt.1: Semiconductor Curve Tracer; Autonomouse The Robot, Pt.2; XYZ Table With Stepper Motor Control, Pt.6; Introducing Home Theatre.

November 1999: Setting Up An Email Server; Speed Alarm For Cars, Pt.1; LED Christmas Tree; Intercom Station Expander; Foldback Loudspeaker System; Railpower Model Train Controller, Pt.2.

December 1999: Solar Panel Regulator; PC Powerhouse (gives +12V, +9V, +6V & +5V rails); Fortune Finder Metal Locator; Speed Alarm For Cars, Pt.2; Railpower Model Train Controller, Pt.3; Index To Vol.12.

January 2000: Spring Reverberation Module; An Audio-Video Test Generator; Build The Picmax Programmable Robot; A Parallel Port Interface Card; Off-Hook Indicator For Telephone Lines.

February 2000: Multi-Sector Sprinkler Controller; A Digital Voltmeter For Your Car; An Ultrasonic Burglar Alarm; Build A Safety Switch Checker; Build A Sine/Square Wave Oscillator.

March 2000: Resurrecting An Old Computer; Low Distortion 100W Amplifier Module, Pt.1; Electronic Wind Vane With 16-LED Display; Glowplug Driver For Powered Model Planes; The Octopus Car Computer, Pt.1.

May 2000: Ultra-LD Stereo Amplifier, Pt.2; Build A LED Dice (With PIC Microcontroller); Low-Cost AT Keyboard Translator; Converts IBM Scan-Codes To ASCII); 50A Motor Speed Controller For Models.

June 2000: Automatic Rain Gauge With Digital Readout, Parallel Port VHF FM Receiver; 1.5V Powerhouse; Power Supply (1.23V to 40V) Pt.1; CD Compressor For Cars Or The Home.

July 2000: A Moving Message Display; Compact Fluorescent Lamp Driver; Bi-Cheapo Musicians' Lead Tester; Li'l Powerhouse Switchmode Power Supply (1.23V to 40V) Pt.2.

August 2000: Build A Theremin For Really Eerie Sounds; Come In Spinner (writes messages in "thin-air"); Proximity Switch For 240VAC Lamps; Structured Cabling For Computer Networks.

September 2000: Build A Swimming Pool Alarm; An 8-Channel PC Relay Board; Fuel Mileage Gauge For Cars, Pt.1; Photoboards – The Easy Way Into Electronics, Pt.1; Cybug The Solar Fly.

October 2000: Guitar Jammer For Practice & Jam Sessions; Booze Buster Breath Tester; A Wand-Mounted Inspection Camera; Installing A Tele-Air Satellite Receiver; Fuel Mileage Gauge For Cars, Pt.2.

November 2000: Santa & Rudolf Chnistie Display; 2-Channel Guitar Preamplifier, Pt.1; Message Bank & Missed Call Alert; Photoboards – The Easy Way Into Electronics, Pt.3.

December 2000: Home Networking For Shared Internet Access; Build A Bright-White LED Torch; 2-Channel Guitar Preamplifier, Pt.2 (Digital Reverb); Driving An LCD From The Parallel Port; Index To Vol.13.

January 2001: How To Transfer LPs & Tapes To CD; The LP Doctor – Clean Up Clicks & Pops In Your Records; Function Generator; 2-Channel Guitar Preamplifier, Pt.3; PIC Programmer & Testbed.

February 2001: An Easy Way To Make PC Boards; Li'l Pulser Train Controller; A MIDI Interface For PCs; Build The Bass Blaster; 2-Metre Ground-Plane Antenna; The LP Doctor – Clean Up Clicks & Pops, Pt.2.

March 2001: Making Photo Resist PC Boards; Big-Digit 12/24 Hour Clock; Parallel Port PIC Programmer & Checkerboard; Photoboards – The Easy Way Into Electronics, Pt.5; A Simple MIDI Expansion Box.

April 2001: A GPS Module For Your PC; Or Video – An Easy-To-Build Video Stabiliser; Tremolo Unit For Musicians; Minimitter FM Stereo Transmitter; Intelligent Nicad Battery Charger.

May 2001: Powerful 12V Mini Stereo Amplifier; Two White-LED Torches To Build; PowerPak – A Multi-Voltage Power Supply; Using Linux To Share An Internet Connection, Pt.1; Tweaking Windows With TweakUI.

June 2001: Fast Universal Battery Charger; Pt.1: Phonome – Call, Listen In & Switch Devices On & Off; Li'l Snooper – A Low-Cost Automatic Camera Switcher; Using Linux To Share An Internet Connection, Pt.2; A PC To Die For, Pt.1 (Building Your Own PC).

July 2001: The HeartMate Heart Rate Monitor; Do Not Disturb Telephone Timer; Pic-Toc – A Simple Alarm Clock; Fast Universal Battery Charger, Pt.2; A PC To Die For, Pt.2; Backing Up Your Email.

August 2001: DI Box For Musicians; 200W Mosfet Amplifier Module; Headlight Reminder; 40MHz 6-Digit Frequency Counter Module; A PC To Die For, Pt.3; Using Linux To Share An Internet Connection, Pt.3.

September 2001: Making MP3s – Rippers & Encoders; Build Your Own MP3 Jukebox, Pt.1; PC-Controlled Mains Switch; Personal Noise Source For Tinnitus Sufferers; The Sooper Snooper Directional Microphone; Using Linux To Share An Internet Connection, Pt.4.

November 2001: Build The Ultra-LD 100W RMS/Channel Stereo Amplifier, Pt.1; A Neon Tube Modulator For Cars; Low-Cost Audio/Video Distribution Amplifier; Build A Short Message Recorder Player; Useful Tips For Your PC.

December 2001: A Look At Windows XP; Build A PC Infrared Transceiver; Ultra-LD 100W RMS/Channel Stereo Amplifier, Pt.2; Pedal Lights – An Intriguing Colour Display; PIC Fun – Learning About Micros.

January 2002: Touch And/Or Remote-Controlled Light Dimmer, Pt.1; A Cheap 12 Easy Motorbike Alarm; 1000VA RMS/Channel Stereo Amplifier, Pt.3; Build A Reactions Alarm; FAQs On The MP3 Jukebox.

February 2002: 10-Channel IR Remote Control Receiver; 2.4GHz High-Power Audio-Video Link; Assemble Your Own 2-Way Tower Speakers; Touch And/Or Remote-Controlled Light Dimmer, Pt.2; Booting A PC Without A Keyboard; 4-Way Event Timer.

March 2002: Mighty Midget Audio Amplifier Module; The Itsy-Bitsy USB Lamp; 6-Channel IR Remote Volume Control, Pt.1; RIAA Pre-Amplifier For Turntable Projects; 12/24V Intelligent Power Battery Charger; Generate Audio Tones Using Your PC's Soundcard.

April 2002: Automatic Single-Channel Light Dimmer; Pt.1; Build A Water Level Indicator; Multiple-Output Bench Power Supply; Versatile Multi-Mode Timer; 6-Channel IR Remote Volume Control, Pt.2.

May 2002: 32-LED Knightrider, The Battery Guardian (Cuts Power When the Battery Voltage Drops); Stereo Headphone Amplifier; Automatic Single-Channel Light Dimmer; Pt.2; Stepper Motor Controller.

June 2002: Look Out The Bad Guys with A Firewall; Remote Volume Control For Stereo Amplifiers; The "Matchless" Metal Locator; Compact 0-80A Automotive Ammeter; Constant High-Current Source.

July 2002: Telephone Headset Adaptor; Rolling Code 4-Channel UHF Remote Control; Remote Volume Control For The Ultra-LD Stereo Amplifier; Direct Conversion Receiver For Radio Amateurs, Pt.1.

August 2002: Digital Instrumentation Software For Your PC; Digital Storage Logic Probe; Digital Thermometer/Thermostat; Sound Card Interface For PC Music Typesetting; Direct Conversion Receiver For Radio Amateurs, Pt.2; Spruce Up Your PC With XP-Style Icons.

September 2002: 12V Fluorescent Lamp Inverter; 8-Channel Infrared Remote Control; 50-Watt DC Electronic Load; Driving Light & Accessory Protector For Cars; Spyware – And How To Update.

October 2002: Speed Controller For Universal Motors; PC Parallel Port Wizard; "Whistle & Point" Cable Tracer; Build An AVR ISP Serial Programmer; Watch 3D TV In Your Own Home.

November 2002: Super Charger For NiCd/NiMH Batteries, Pt.1; Windows-Based EPROM Programmer, Pt.1; 4-Digit Countdown Timing Module; Using Linux To Share An Optus Cable Modem, Pt.1.

December 2002: Receiving TV From Satellites; Pt.1: The Microminitter Stereo FM Transmitter; Windows-Based EPROM Programmer, Pt.2; SuperCharger For NiCd/NiMH Batteries; Pt.2; Simple VHF FM/AM Radio; Using Linux To Share An Optus Cable Modem, Pt.2.

January 2003: Receiving TV From Satellites, Pt.2; SC480 50W RMS Amplifier Module; Super Charger For Cars; Active 2-Way Crossover For Speakers; Using Linux To Share An Optus Cable Modem, Pt.3.

February 2003: PortaPal Public Address System, Pt.1; 240V Mains Filter For HiFi Systems; SC480 50W RMS Amplifier Module, Pt.2; Windows-Based EPROM Programmer, Pt.3; Using Linux To Share An Optus Cable Modem, Pt.4; Fun With The PICAXE, Pt.1

March 2003: LED Lighting For Your Car; Peltier-Effect Trinnie Cooler; PortaPal Public Address System, Pt.2; 12V SLA Battery Float Charger; Build The Ultimate Subwoofer; Fun With The PICAXE, Pt.2 (Stepper Door Minder); SuperCharger Addendum; Emergency Beacons.

April 2003: Video-Audio Booster For Home Theatre Systems; A Highly-Flexible Keypad Alarm; Telephone Dialler For Car Burglar Alarms; Three Do-It-Yourself PIC Programmer Kits; More Fun With The PICAXE, Pt.3 (Heartbeat Simulator); Electric Shutter Release For Cameras.

May 2003: Widgybox Guitar Distortion Effects Unit; 10MHz Direct Digital Synthesis Generator; Big Basher Subwoofer; Printer Port Simulator; More Fun With The PICAXE, Pt.4 (Motor Controller).

June 2003: More Fun With The PICAXE, Pt.5; PICAXE-Controlled Telephone Intercom; PICAXE-08 Port Expansion; Sunset Switch For Security & Garden Lighting; Digital Photo Timer; Adjustable DC-DC Converter For Cars; Long-Range 4-Channel UHF Remote Control.

July 2003: Smart Card Reader & Programmer; Power-Up Auto Mains Switch; A "Smart" Stove Flash Trigger; Programmable Continuity Tester; PICAXE Pt.6 – Data Communications; Updating The PIC Programmer & Checkerboard; RFID Tags – How They Work.

August 2003: PC Infrared Remote Receiver (Play DVDs & MP3s On Your PC Via Remote Control); Digital Instrument Software For The PC, Pt.1; Home-Brew Weatherproof 2.4GHz WiFi Antennas; PICAXE Pt.7 – Get That Clever Code Purring; A Digital Timer For Less Than $20.

September 2003: Robot Wars – The Sport Of The New Millennium; Bright & Cheap Keyring Bike Light; Portable PIC Programmer; Current Clamp Meter Adaptor For DMMs; PICAXE Pt.8 – A Data Logger & Sending It To Sleep; Digital Instrument Software For Cars, Pt.2.

October 2003: PC Board Design Tutorial, Pt.1; The JV80 Loudspeaker System; A Dirt Cheap, High-Current Power Supply; Low-Cost 50MHz Frequency Meter; Long-Range 16-Channel Remote Control System.

November 2003: PC Board Design Tutorial, Pt.2; A 12AX7 Valve Audio Preamplifier; Low-Cost LED Torch; Simple Radio Modem For Microcontrollers; PICAXE Pt.9 – The 18X Series; Programmable PIC-Powered Timer.

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Valve substitute for preamp

I am just wondering if a 12AU7A would be OK for the preamp circuit featured in the November issue. It's an old AWA Radiotron. Also, is it true that valves contain mercury? (L. A., via email).

● Yes, you can use a 12AU7. It is a lower gain device but since feedback is applied around the circuit, it will make little difference. As far as we know, there is no mercury contained in thermionic valves or used in their manufacture. The shiny appearance inside the tube is not mercury but the metallisation deposited when the getter ring (containing barium or magnesium) is activated after the valve has been evacuated.

CDI for vintage motorbikes

Back in July 1975, "Electronics Australia" came up with a modified design of the August 1970 CDI. I made up some of these and they are still running. I have only had one failure of a polycarbonate capacitor and even this was no drama as I had a spare in place. 28 years is not a bad effort and still going.

I have a collection of vintage motor motorcycles that used to have magnetos; ie, no distributor. I modified the EA circuit to the extent that I had two "steering diodes" just after the bridge rectifier. Each steering diode went to trigger circuits and hence to individual HT coils for each cylinder (twin cylinder 50° V). This works just fine.

What I would like to know is could the Programmable Ignition Module that's used to enable electronic advance (SILICON CHIP, March 1996) be used to interface with the 1975 CDI? I love CDI as it fires oily plugs, etc that abound on old bikes, no matter how good the engine condition is.

Failing that, I know that it does work with your High Energy Ignition (SILICON CHIP, June 1998). The problem is that old bikes do not have the kind of generation power of cars so that current draw has to be considered. The High Energy Ignition kit has provision for two sets of points. Could I use that feature to fire a 2-cylinder motor cycle with *no* high tension distributor cap? In other words, use a HT coil with two HT leads, having a waste spark on the exhaust of the cylinder that is not on compression (like a Harley)? I would dearly love to get rid of the mechanical advance unit that wears considerably. (D. A., via email).

● Stick with your simple approach. Do not even consider the HEI as it needs heaps of current and won't necessarily do a better job of firing oily plugs. Don't bother with the PIT module either – it's too much trouble. You will need to build an interface to allow it to drive the old CDI and you need to derive 5V for it too.

Exhaust gas tester for Citroen

I have assembled the Exhaust Gas Oxygen tester kit and fitted it to a 1999 Citroen Xsara. The sensor wire from the tester is connected to wire 131 at pin 4 of the oxygen sensor (see Sagen SL 96, Citroen diagram).

The voltage on this wire bounces from .01V to 0.9V and the red and yellow LEDs seem to correspond to the voltage swings. However, the green LED is on all the time, even when the engine is switched off for hours. When the sensor wire is not connected, the red LED is on which the instructions indicated would be normal. This is the only time the green LED is off.

During assembly, the only query I had is regarding the locations of the capacitors, as the drilled holes in the circuit board would suggest they be fitted opposite to the component diagram. That is, the distance between the legs would fit the circuit without bending the legs if they were fitted opposite to the drawings. (C. S., via email).

● We assume you're referring to the Low Cost EGO Tester published in the

Checking The Fuel Mixture Display

I recently built and installed a Fuel Mixture Display kit from the November 1995 issue of SILICON CHIP. I went overboard on building it correctly and I am now puzzled.

Either my car's oxygen sensor has had it or it doesn't get into closed loop mode. With the car warm and the ignition on but the motor not running, the farthest rich LED lights up. It is the same when the engine is running and does not change under any conditions at all. Setting the trimpot to either extreme doesn't change anything – it just sits on that most rich LED.

The kit does not smell or anything so and I am sure I built it correctly. The car has a constant 800mV at idle when warm. This reading could be "stuck" and could be the case all the time. My question is, should the kit display that LED when the engine is not running but with ignition switched on? (A. P., via email).

● The way to test the unit would be to connect a 10kΩ trimpot between +12V and ground with the wiper connection to the input of the display unit. Adjust the trimpot to produce an output between 0V and 1V, as measured at the wiper. This should cause the LED display to range from fully lean to fully rich, depending on the setting of the trimpot.

If there is no response and the circuit doesn't work, the problem is in the circuit. If the circuit works, then the sensor may be faulty.

February 1994 edition of "Electronics Australia". If the unit is operating properly, the green LED should only be on when the input voltage from the sensor is between 0V and 0.2V. This does mean that it will be on when the engine is not running. However, it also means that it should be off when either the yellow or red LEDs are on.

Check the threshold voltages on pins 10 & 2 of IC1. These should read about 0.2V and 0.6V, respectively. Note that you should connect the power (+13V to 15V) wire from the board to the ignition switch circuit, such that it is not powered when the engine is off.

The capacitors (C1, C2) must be mounted as shown in the component overlay diagram.

UHF to VHF converter

I need to build or buy a UHF (specifically channel 31) downconverter to VHF (specifically channel 6 or 8). Please can you tell me if you or your sister magazines have ever published a project which I could construct directly or modify? The signal levels involved are normal TV reception ones. (W. B., via email).

● We have not described a UHF to VHF TV converter and we don't think there would be much interest in such a project. Perhaps the easiest approach would be to use an old VCR with a VHF modulator output. They can be easily picked up on council clean-ups.

The VCR's output would normally be on channel 0 or 1 but it should be reasonably easy to modify the VCR's modulator to run on channel 6 or whatever by changing the inductance in its tank circuit. Alternatively, can you use the video output of the VCR and feed that into your friend's set?

Running the LED torch from 4.5V

The LED torch in the November issue looks like a very exciting project to build. Is it possible to run the Luxeon LED from three D cells (4.5V), thus eliminating the step-up DC-DC converter? (C. N., via email).

● Well, yes, but . . . the Luxeon could be driven from a 4.5V source but a 3.3Ω 1W current limiting resistor would be required. This would work fine when the batteries were fresh but once they got down to about 3.5V (1.17V/cell) the brightness would be woeful, so the overall battery life and utilisation would be very poor compared to our design using a DC-DC converter.

RLC network in amplifier modules

For some years, I have been using three of the 100W amplifier modules published in the December 1987 issue of SILICON CHIP. These have performed well and without fault.

I read with interest your new design of January 2003 and thought about updating the modules. In the event, I decided this was not worthwhile as the new circuit is similar to the previous design and although the PC boards and earthing modifications are no doubt an improvement, I thought the benefits would be marginal.

However, I did decide to check the performance of the modules and discovered that the output is significantly affected by the capacitor of the RLC network. The recommended 150nF component results in significant overshoot on a 10kHz square wave (into 8-ohm loads – all three modules give the same response).

Reducing the capacitor to 100nF gives an improvement but 47nF gives the best result and appears to maintain stability. No capacitor results in oscillation at high signal levels. I would much appreciate your comments on these observations and also why you did not use the normal Zobel arrangement of a resistor and capacitor before the output inductor. 100nF in series with 10Ω here also gives a good square wave and stability. (D. A., Aspley, Qld).

● The RLC network we have used in all our amplifier designs is based on a design by Neville Thiele (of Thiele/Small fame) published in the "Proceedings of the IREE", September 1975.

It has the advantage of combining the Zobel network with a commonly used RL network used to isolate the amplifier from large capacitances which can cause instability and latch up. It also helps attenuate RF signals picked up by the speaker leads which can otherwise be coupled back via the feedback network into the input stages.

However, the values are a compromise, depending on whether you are driving 4-ohm or 8-ohm loudspeakers. We tend to go for the larger value – ie, 150nF – to ensure stability and overall good behaviour on the impedance dips which are inevitable with all real loudspeakers.

Silicon bilateral switch unavailable

In your September 1992 edition, you published an article on building a universal motor speed controller. I'm keen to build this, for use as a speed control on a 1950s Kenwood Chef food mixer, to replace the old contactor bar. But I am having a lot of trouble sourcing a 2N4992 silicon bilateral switch (200mA 300mW) as specified in the circuit.

Can I use two back-to-back 7.5V zener diodes to control the Triac gate? (N. R., via email).

● Have a look at the updated speed control in the October 2002 issue. It solves the 2N4992 problem by using a C103B as the trigger device. You can't use back-to-back zeners because the trigger device needs a negative resistance to ensure a healthy trigger pulse. A new PC board is required, however. We can supply the October 2002 issue for $8.80 including postage.

Help with a DPM connection

A friend purchased a Jaycar LED Panel Meter (QP5580) and it works fine if you have the meter supplied from a battery and the voltage to be measured is completely separate. But how on earth can he connect the supply through a drop-down regulator and measure the raw supply voltage with the same meter?

He needs to make it a simple voltmeter that can plug straight onto a battery under test and read off the voltage without having to resort to the extra batteries for the DPM supply. The meter is a "common ground" and supply

Suitability of SC-480 for guitar use

I have a couple of questions regarding the 50 watt SC-480 amplifier from the January & February 2003 issues. I am planning to use it as a guitar amplifier. Would it be suitable? If so, what (if anything) would need to be added to it for it to work, such as a preamp?

What would I use as a volume control and where? Would this circuit benefit by regulating the power supply? (A. H., via email).

● The SC480 is fine for guitar work. Have a look at the following guitar preamps: 4-Channel Guitar Mixer in January 1992; 2-Channel Guitar Mixer (includes electronic reverb) in November/December 2000 & January 2001. Or if you just want a very simple preamp with 3-band tone controls, you could adapt the Guitar "Widgy" box from the May 2003 issue. We can supply these magazines for $8.80 each, including postage.

The preamps listed all have their own volume controls. There would be no benefit from regulating the amplifier's power supply.

is 5V. He has also purchased the add-on board to set the decimal point and the voltage scale (20V in this case).

The main problem is that in the heat of a corrugated iron pump cover out the "back-o-Bourke", alkaline or NiCad/NiMH batteries suffer and die very quickly. (S. B., via email).

● You need a level shifter circuit to accommodate the fact that the LCD meter needs to be connected to a raised (or isolated) earth. Have a look at the 40V power supply in the January & February 1994 issues of SILICON CHIP.

Essentially, the relevant part of the circuit (in the January issue) is IC4 which shifts the voltage by an offset. The op amp attenuates the voltage to suit the 2V scale. Note that point X shown for IC4's 100kΩ feedback resistor can be ground as it is only across the current sensing resistor R1.

More current from the DC-DC converter

Thank you for featuring the DC-DC Converter in your June 2003 issue. I am an instrument technician and do service work on job sites. My work requires a laptop computer and I am using an old Toshiba Satellite which requires 15V DC at 3A. Is there a way to upgrade the converter to 3A or 4A? (B. R., via email).

● The circuit can deliver up to 4A if the 0.1Ω sensing resistor is paralleled with another 0.1Ω resistor and the fuse rating is increased to 5A. Also, each of the low ESR capacitors will need to be paralleled to increase the ripple rating. Finally, the diodes and Mosfet will need larger heatsinks.

Query on the battery desulphator

I'm interested in building the battery desulphator described in the Circuit Notebook pages of the February 2003 issue but I cannot understand why the Mosfet source connection goes to +12V and the drain goes to ground. It's usually source to earth! Also why use a P type when there are more N types available? (D. H., Shepparton, Vic).

● Q1 is a P-channel Mosfet, signified by the arrow from the gate to the source. Therefore, source does go to +12V. Perhaps we should have mentioned that in the short circuit description. You could turn the whole circuit upside down to use an N-channel Mosfet but then you would have to swap R1 and R2 to give correct pulse duty cycle from IC1.

High-quality AM tuner wanted

How about designing a quality AM tuner capable of full bandwidth, with an audio line level output to feed to an existing hifi system? It seems that the majority of AM tuners available are of poor quality and have limited bandwidth etc. (W. N., Casino, NSW).

● We have published two high quality stereo AM tuners in the past: the Portable AM Stereo Tuner in September, October & November 1989, and the Wideband AM Tuner in February, March & April 1991. We can supply the 1989 articles in photostat form and the 1991 magazines for $8.80 each, including postage.

Protection for DC plugpacks

Is there a way to prevent ignorant, clumsy souls like me from destroying my 12V DC plugpacks? Will a zener diode do it? R. L., via email).

● You need a fuse. Try connecting a 1Ω 0.25W resistor in series with the plugpack's output. Hopefully it will blow before any serious damage is done. SC

Notes & Errata

Gear Indicator, January 2003: the pin 2 & 3 connections for the Hall effect sensor (UGN3503) are shown transposed on the circuit diagram (Fig.7). Pin 2 should be GND and pin 3 the signal output. The overlay diagram is correct.

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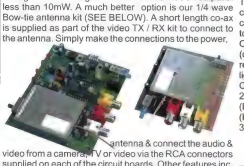

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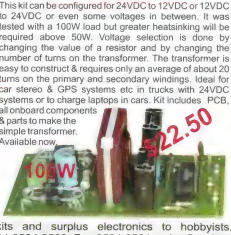

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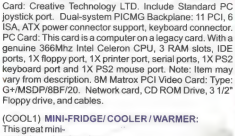

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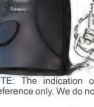

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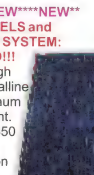

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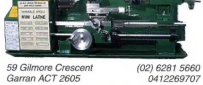

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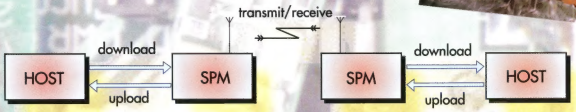

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